THE ADVANCEMENT OF SCIENCE

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SCIENCE AND THE CITIZEN:
THE PUBLIC UNDERSTANDING OF SCIENCE

TRANSACTIONS OF A CONFERENCE HELD BY THE DIVISION FOR THE SOCIAL AND INTERNATIONAL RELATIONS OF SCIENCE, MARCH 20–21, 1943

THE contents of this number of *The Advancement of Science*, like previous numbers in Vol. II, which the present issue completes, record results of the Association's war-time policy of dealing, through its Division for the Social and International Relations of Science, with scientific subjects of importance in relation to post-war reconstruction, which were touched upon in the course of the Conference on Science and World Order, held in September 1941. The Conference on Science and the Citizen, reported below, was held in the theatre of the Royal Institution, Albemarle Street, London, by kind permission of the Managers of the Institution, and the gratitude of the Association is due both to them and to members of the staff of the Institution for their generous help.

MESSAGE FROM
THE RT. HON. SIR JOHN ANDERSON, P.C., M.P.,
LORD PRESIDENT OF THE COUNCIL

(This message was communicated to the audience on two occasions during the Conference. Messages received after the Conference will be found at the end of the transactions.)

IN all its 112 years of a very active life, the British Association can scarcely ever have set its hand to a task of greater potential value to the community than that which it is now undertaking. It is only a logical consequence of the Association's pioneer work in taking science to the citizen, in a long succession of annual meetings, that it should now provide a platform for a public discussion of the effects science, and the applications of scientific discoveries, may have upon the fuller life that mankind hopes to see emerge from the present world conflict.

Everyone now realises how large a part science is playing in the war : indeed it has now become a cliché of popular journalism to say that this is a scientists' war. On the other hand, it is not always so clearly recognised that the scientific advances that have been made in recent years will have equally far-reaching effects on the lives men hope to lead when peace returns.

We must recognise that the Government of the day showed great wisdom and foresight when, at the height of the last war, it established the Department of Scientific and Industrial Research so that, by precept and practice, it might guide industry into a fuller understanding and use of the help science could give. The Medical Research Council and the Agricultural Research Council soon followed, and I now have the honour to preside directly over a group of research organisations which, together with the research organisations of industry and the laboratories of universities and private investigators, will have a vital contribution to make to the solution of post-war problems. But that contribution can only become really effective if the general public appreciate not only the powers but the limitations of scientific research. Much harm may be done if those without scientific training are encouraged, by well-intentioned but extravagant advocacy of the marvels of science, to expect from science alone remedies for all the social problems with which we shall be faced. Indeed, the full harvest of the national scientific effort will not be reaped unless the same intensive and penetrating consideration is given to the application of scientific results as was called for in their original accumulation.

The British Association is therefore performing a valuable public service to-day in promoting this organised examination of the impact of scientific and technological advances on the changing social order. No organisation is better fitted by tradition or breadth of interest to do so.

THE EXPOSITION OF SCIENCE

Saturday, March 20 : Morning Session

Opening by Sir Richard Gregory, Bt., F.R.S., President of the Association

Through the courtesy of the Managers of the Royal Institution we are privileged to meet in this historic building for a Conference on Science and the Citizen. For nearly a century and a half this Institution has been a centre of light and leading in the realm of natural knowledge. It was founded to aid the development of the natural resources of the country and also for 'the diffusion and extension of useful knowledge in general.' In the adjoining laboratories discoveries have been made which have shaped the structure of civilised life. In this lecture theatre advances in all branches of pure and applied science have been described by the chief creators of them, and leading authorities in literature, art, music, drama and other fields of intellectual culture have also given addresses.

The greatest of these makers of modern history was Michael Faraday, who for more than fifty years was the soul of this Institution and for the main part of the period was the foremost lecturer on science in London. The best lectures on the course of the living stream of science are those given at the fountain-head. It is particularly appropriate, therefore, that the opening session of this Conference should be devoted to the subject of the exposition of science and that Sir Henry Dale, the Director of this Institution, should be its Chairman.

Scientific lectures appeal, however, only to members of the public who are prepared to exercise a certain amount of mental effort to comprehend their meaning. Faraday had this educational condition in his mind when he said : 'Lectures which *really teach* will never be popular : lectures which are popular will never *really teach*.' Through broadcasting and the cinema, the whole world can now see and hear speakers on scientific subjects as elements of popular entertainment, and they have proved to be most valuable equipments to increase public understanding of scientific work and achievement.

Devotion to the pursuit of natural knowledge must not be measured by practical service alone. The function of scientific investigators is to discover natural facts and relationships ; material advantages may or may not be derived from the results of their enquiries. Whether good or evil uses are made of these discoveries depend upon the aims and character of the community rather than upon the studies themselves.

This has been so from the beginning of civilisation, but there has always been a lag between stages of scientific knowledge and social or moral wisdom. What is particularly needed to-day is to promote public interest in the close relationships of natural science with other humanistic studies which influence the thoughts and actions of all citizens. It is in this social spirit that the present Conference has been convened, and not in that of the separate interests of science in cultural development.

I have, therefore, much pleasure in asking Sir Henry Dale, the President of the Royal Society, whose whole scientific work has made human life richer and safer, to take the chair at this session of a Conference on Science and the Citizen.

Address by Sir Henry Dale, G.B.E., Pres. R.S. Chairman

Under the general title Science and the Citizen, this Conference is invited to consider especially the Public Understanding of Science, and the methods of promoting that understanding. It is not my purpose to stand long between you and the effective contributors to the practical discussion of a matter of such central and vital interest to any modern community. Perhaps you will allow me, however, very briefly to remind you of some points in the history and the associations of the place in which this Conference is being held.

The chief author of the movement, which led to the foundation of this Royal Institution of Great Britain, was a man of widely international associations and loyalties. Born as Benjamin Thompson, a citizen of Britain's North American colonies, he fought against the majority of his countrymen in their War of Independence, retained his British nationality, and, before he entered the service of the Elector of Bavaria, had held appointments under two Departments of the British Government. Made a Count of the Holy Roman Empire for his distinguished services to the Elector and the people of Bavaria, he took his title from Rumford, an earlier name of Concord, in New Hampshire ; and it was as Count Rumford that he was best known in London, to which he returned in 1798. A man of science well in advance of his own times, particularly in his understanding of the nature of heat and his experimental determination of its mechanical equivalent, a recipient of the Royal Society's Copley Medal in 1792, Rumford had given himself to philanthropic and administrative reforms in Bavaria, and, in particular, to the enterprise of applying scientific knowledge and invention directly to the betterment of domestic conditions. Thus he had promoted the economical and efficient use of fuel by designing better stoves and appliances for domestic heating and cooking. The same desire, to spread the knowledge of science and to promote its general use by the ordinary citizen, was evidently strong in him when he returned to London. With these objects he associated himself with the Society for Bettering the Conditions and Increasing the Comforts of the Poor. The title, with its bland implications, may sound priggish to a modern ear ; but the association should not blind us to the far-seeing

generosity of Rumford's plans. He enlisted also the interest of his powerful scientific friend, the then President of the Royal Society, Sir Joseph Banks; and it was at Banks' house and under his chairmanship that a meeting was held, on March 9, 1799, which resulted in the foundation of this Institution: 'For diffusing the knowledge, and facilitating the general introduction, of useful mechanical inventions and improvements: and for teaching, by courses of philosophical lectures and experiments, the application of science to the common purposes of life.' With a sufficient allowance for the change in sociological background, and with some shift of emphasis, perhaps, to give clearer recognition to the cultural as well as the directly material value of scientific knowledge, I do not think that the objects which Rumford and his associates set before them were widely different from those with the promotion of which this Conference is to concern itself.

Rumford's own conception of the Institution recognised two sides to its activities. On the one hand it was to have workshops and model kitchens for improving and teaching the mechanical and domestic arts on the best scientific principles; on the other hand, there were to be professors to expound the wonders of science to the nobility and gentry, whose subscriptions would maintain the Institution. Perhaps this Conference may see an analogy not too distant, if it should find itself also considering methods of ensuring an adequate understanding of science by two different sections of the public—the general body of the ordinary citizens on the one hand, and, on the other hand, those responsible for government, for the making and administration of the laws; the members of both Houses of Parliament, the Ministers of the Crown, and, perhaps the most important of all, the higher ranks of the Civil Service.

Rumford's original conception of the dual function of the Royal Institution did not survive his return to the Continent in 1802, and concern for the training in science of the rank and file of the people, which had figured so prominently in his original plans, was soon allowed by the other Managers to drop out of sight. Before Rumford left, however, the appointment to professorships at the Institution of two men who were to become investigators of outstanding eminence, Humphrey Davy and Thomas Young, had launched the Institution on a new career. In this, though it has differed from that projected at its foundation, the Institution may properly claim to have done outstanding service, not only to the advancement of scientific knowledge by research, but also to the understanding of science by an important section of the public and, less directly, by a much wider body of the people of this country. It has been the good fortune and the high distinction of this Institution to have had on the roll of its professoriate a number of men who, while standing in the first rank as original investigators, have at the same time achieved pre-eminence as popular expositors of science. To name those who, over 140 years, have combined here the functions of professor and resident superintendent, I think that this Institution could challenge the world to produce elsewhere a succession of discoverers, expositors and demonstrators to rival that of Humphrey Davy, Michael Faraday, John Tyndall, James Dewar, and William Bragg. Among others who have been professors here we may note, in addition to Thomas Young, the late Lord Rayleigh, Sir J. J. Thomson, Lord Rutherford and, most brilliant expositor of them all, Thomas Henry Huxley—Huxley, the most doughty and incisive champion in our language of the claims of the people to a knowledge of science, and of science to be regarded as a staple of education and not merely as an ornamental fringe.

I venture to suggest, then, that this Conference may find some encouragement and inspiration in the fact that it is meeting here in this theatre, which has for so long been one of the chief temples of the public understanding of science, even though its public has been, perhaps, rather exclusive. It has provided, for many outside the immediate circle of active workers in science, a first opportunity of contact with new discoveries and advances; and I hope that its services in that direction, as in others, may experience a full revival when scientific activities return to their normal channels with the coming of peace.

But the discussions at this Conference will doubtless deal with the public understanding of science from the much wider point of view of the needs of the whole nation and of the world. For we are rapidly moving, have already moved far indeed, though without any general awareness, into an era in which the discoveries of science can no longer be regarded as something extraneous or additional, but have become an essential constituent of the common fabric of our everyday life; an era in which some knowledge of science is no longer a personal foible, or merely a convenient aid to certain types of industrial enterprise, but has become a necessity of any reasonably civilised life. War diverts science from its civilising functions, but in due course we shall find that it has given a forced acceleration to developments which, when the war reaches its end, will bring a rapid reshaping of the activities of mankind at peace, involving a yet closer dependence of daily life on science, and a corresponding increase of the need of everyone to understand its meanings.

I must not let myself be drawn into the detailed discussion which belongs to those who follow; but I should just like to say in conclusion, that the public understanding of science will need for its achievement the co-operation of the two parties concerned—to speak in the terminology of broadcasting, it will require an efficiency of the transmitter and a tuning of the receivers, which only the proper conditioning can provide in either case. The transmitters, the men of science, will certainly continue to differ widely in their natural gifts for simple and vivid exposition; but it will be an increasing obligation for them to make the best of a natural endowment, or to rise above a natural lack of it, by conscious and diligent study of the means, including the new techniques which science itself provides, for interpreting and expounding its problems and its achievements to an ever widening audience. On the other hand there is the much greater problem of preparing a whole people to receive the message. I feel that it is time for us to say, boldly and clearly, that tinkering and patching are not enough, and that to enable this country to play its part in the

civilisation now in the making, and to keep step in the march of progress with the other great world communities, nothing will suffice short of such a recasting of our schemes of education as will give to science its proper and central place at every stage—in elementary, secondary, university and adult education.

Sir Lawrence Bragg, F.R.S.

I INTERPRET the subject of the exposition of science widely, as covering the various ways in which the scientific expert can explain to the non-scientist what he is doing. The lecture is only one means of effecting this end; education, articles and books, broadcasting, personal contact between scientists and industry and scientists and the Government all enter into the problem, and come under the head of the exposition of science.

Place of Science in the Modern World.—At present there is a very small body of pure scientists engaged in adding to scientific knowledge, a not much larger body of applied scientists using that knowledge for industry, and a general public, including most of our leaders, to whom science is a sealed book. This is dangerous, because we are at the beginning of an era in which the material conditions of life are being profoundly modified by the results of scientific investigation. We cannot plan wisely for the future unless there is a widespread general understanding of what science is and what it can do.

Popular Science.—Scientists are often accused of being too technical in their presentation of their subject. There is some truth in this. The giving of a popular lecture or writing of a popular article is more difficult than talking to fellow experts, and not all can master the art. However, the scientist's difficulties must be realised. He is warned not to use technical terms, but if in a lecture one has to state everything in general terms no time is left to explain the main points. What could be more technical than a description of a football match? To picture the scientist's plight, one must imagine the sports expert being told to describe the match using as little as possible such technical terms as 'ball' or 'goal,' and of course avoiding the very complex ideas involved in 'try' or 'offside.'

The real trouble is that science has not been regarded as an essential part of a balanced education, as it should be. The humanities and the sciences are equally important ingredients of education. It would clearly be wrong to give an entirely scientific training at school, omitting English, history, or the languages, and I doubt whether such narrow specialisation has ever been attempted. Yet its counterpart is only too common, an education which has omitted the sciences entirely. However, a knowledge of science is rapidly becoming more widespread. It is much easier to give a popular scientific lecture to young people than to their parents; they have a background and both understand the points and appreciate the interest.

Evidence of the widespread ignorance of science is to be seen in the very low level of journalistic reports of scientific discourses or discoveries, as compared with reports on politics, music, drama, literature, art or sport.

The Art of the Popular Lecture.—The popular lecture can be a very powerful weapon, and its proper planning and delivery is a most interesting art. Its structure should be much like that of a good play; in fact, it must be dramatic if it is to be successful. It is as important to preserve the unities of the lecture as the unities of the drama, and everything that does not lead up to and support the one main theme of the lecture must be ruthlessly pruned away. It is as inartistic to have more than one main theme as it is to have more than one centre of interest in a picture. It is necessary to take a realistic view of what can be achieved in a lecture. The net effect is that which the members of the audience remember, what in fact they tell a friend who asked them what the lecture was about. A lecture is a success if the members of the audience go away with one good idea firmly implanted in their minds; a daring man may try to increase this to two, but more should never be attempted. The art of giving a good popular lecture, in short, is largely the art of what to leave out.

Arrangement is very important. A point should never be explained until the audience has been made to realise that there is a point to explain. It is easy to fall into the trap of reversing this order, but if one does so the impression on the audience is like that on the reader of a detective story who is told the solution before he has racked his brain to think of the significance of the clues.

The experiments which illustrate a popular lecture must be of a special type. Bad experiments are those in which the audience cannot see the workings, but only the movings of a pointer indicating an effect. However fine the technical achievement required to make the experiment work on the lecture-bench, the audience must take the lecturer's word for its difficulty, and depend on him for an explanation of its significance. The best experiments are so simple as to be almost homely. They must if possible be related to something the audience knows in everyday life and generally takes for granted, such as an experiment casting light on a well-known fact from a new angle. The element of surprise is important.

It should be a point of honour never to read a lecture, but always to think it out as one goes along, with the aid of very brief notes. The spoken lecture is completely different in style from the written article. Very few people can read a lecture without going much too fast, and adopting too monotonous a pace. Nothing has so soporific an effect as a steady pace in a lecture.

The lecturer should always start with something which the audience knows perfectly well. He should always watch the faces of his audience, and continually replan the lecture as it goes on by noting the response he is getting.

The most difficult trap of all to avoid, into which even the experienced lecturer is apt to fall, is that of trying to say too much. This is particularly dangerous in a subject which one knows really well, because one tends to telescope in one's own mind a series of steps of reasoning which one has traversed very often, and does not realise how long it will take to get the audience to follow them. A disastrous result is that one spends too long over the early part of the lecture, and has not time to do justice to its grand finale. The available time,

for instance fifty minutes for the hour's lecture, should be divided amongst the sections of the lecture, and the time at which each section is to be completed should be indicated on the margin of one's notes.

Lecturers should occasionally ask a friend whether they are making their voices carry to the back of the room.

These may seem very obvious points, but it is surprising how often lecturers who have the most interesting message to convey fail to do justice to it by neglecting one or more of them.

Science and Industry.—A very important relation between the scientist and non-scientist is that between the scientific expert and industrial leaders. We have a number of fine industrial laboratories in this country, but we cannot consider we are making full use of our scientific assets when we compare ourselves with Germany and America. The leaders of industry often owe their positions to their commercial and financial ability rather than to their technical ability. A story of an American president of a large concern, related by a recent visitor to the States, illustrates the difference in point of view. When asked whether his large laboratory was justified by results, he warmly asserted that it was, and added that apart from any financial considerations he would not give it up because it was the most interesting part of his business. Scientists are too often regarded as experts to call in when there are troubles, not as colleagues to call in when making plans. They are allowed to give tactical help, but not to take part in strategy. Again, education has been to blame and should provide the cure.

Science and Government.—Another important relationship where scientific exposition is needed is that between the scientist and the politician. When the Government feels the need of scientific assistance it generally has recourse to the appointment of an advisory committee. Such bodies are very useful, but not a complete solution of the problem. They are generally composed of well-known and therefore busy people, who are on a number of such committees, and cannot give more than a fraction of their time and interest to each. They therefore cannot get an intimate knowledge of the problems and the men engaged in solving them. A scientific analysis of this country's assets in the way of scientific consultants should be made, together with the needs for employing them. The number of such people is limited, and they should be rationed out amongst the fields where they are in demand, so that any one man can give a really large part of his time to intensive study of one or two fields. He will be far more useful in that way than when serving on numerous advisory bodies which meet at short intervals. The necessity of appointing a committee ' representing all interests ' is a fetish, except in the case of bodies which meet at long intervals. A good scientist knows whom to consult in any special field, and can go to that person for guidance when the problem is not one with which he is familiar.

In conclusion, the need for a more widely diffused knowledge of science is only one aspect of a wider problem. The mind can be trained through hand and eye as well as by books, and our education has become too bookish. The avidity with which young people have taken up various forms of manual work during the war, and the appreciation they have shown of the mild responsibilities associated with it, is evidence of a psychological need for something they do not get from their books, or for the matter of that from their games. They enjoy doing something useful with their hands, and seeing the concrete evidence of their labour. Manual dexterity, craftsmanship, and science, and the methods of thought which they engender, must rank with the humanities in a balanced education.

Prof. Allan Ferguson

THERE is danger in associating the origin of a revolution in thought with a definite date, but that great movement for which Francis Bacon rang—or asserted that he rang—the bell to call the wits together may conveniently be assumed to date its origin at the end of the sixteenth or the beginning of the seventeenth century, when Galileo laid the foundations of the science of dynamics and Gilbert of Colchester published the first fruits of a new system of philosophy, which he very emphatically refused to submit to the judgment of ' men who have taken oath to submit to the opinions of others, to the most senseless corrupters of the arts, to lettered clowns, grammatists, sophists, spouters, and the wrong-headed rabble, to be denounced, torn to tatters, and heaped with contumely.'

That movement culminated in the seventeenth century with the publication of the *Principia* in 1687.

We can give an intellectual assent to many of the statements concerning the importance of the *Principia* in the history of the development of physical science, but the *Principia* is a book which in these days is more honoured than read and it is no easy matter to appreciate fully its immense sweep of thought and its impact on the physical notions of the period. More than any other book, the *Principia* was responsible for the mechanical view of the phenomenal world which has lasted until our own day, and which still persists as the most convenient mode of description of many large-scale events. The effect on the outlook in Britain was immediate and profound. In the Universities, Whiston in Cambridge, Keill in Oxford and Gregory in Edinburgh were protagonists in the teaching of the new philosophy, and Keill was, I believe, the first teacher in Oxford to give experimental illustrations in lectures on physical science.

The published work of these pioneers led the way for a spate of lectures on physical and chemical science whose influence, in the aggregate, must have been profound. With the advent of the Industrial Revolution the desire for a knowledge of science spread more and more widely, from the metropolis to the provinces, from the dilettante aristocrat to what were known, in Victorian days, as the operative classes [1]; the

[1] In the annals of our own Association, it is recorded that, at the Annual Meeting at Dundee in 1867, a series of what were entitled ' Lectures to the Operative Classes ' was instituted, when John Tyndall led off with a lecture on ' Matter and Force.' In 1911, the title of the series was altered to ' Public Lectures.'

Royal Institution was founded at the turn of the eighteenth century (1800) 'for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions . . . for teaching by courses of philosophical lectures and experiments the application of science to the common purposes of life.' Mechanics' Institutions were multiplying rapidly in the early years of the nineteenth century; and by the 1830's the Society for the Diffusion of Useful Knowledge, under the lead of the energetic Brougham, was spraying its pamphlets over the length and breadth of the land, to the undisguised disgust of such upholders of the old classical tradition as the Reverend Dr. Folliott, whose gibes at the march of mind, the learned friend and the Steam Intellect Society form not uninstructive reading, even to-day.[1]

All these activities involved very considerable, and expert, exposition of science, and, when we honour the memory of Faraday, it were well to remember the heroes who lived before Agamemnon, and who are, names indeed, but little more than names, to-day. May I remind you, therefore, of Samuel Kaye, who, in 1743, gave in Manchester a course of twenty-four lectures on Mechanics, Optics and Astronomy? of Tatum, whose lectures in natural philosophy were given at his house, 53 Dorset Street, Fleet Street? Faraday, as a seventeen-year-old youth, attended a course of these lectures which were advertised 'by bills in the shop windows near his house. The hour was eight o'clock in the evening and the charge was one shilling per lecture.' Even the great John Dalton—when very young, it is true—essayed in 1787 a course of twelve public lectures on mechanics, optics, pneumatics, astronomy and the use of the globes—fee for the whole course, half a guinea! Dalton, who can hardly be ranked as a great expositor, was destined a quarter of a century later to give courses on natural philosophy of a very different quality to a very different audience. In 1803 and again in 1809 he delivered courses of lectures at the Royal Institution which attracted audiences of from one hundred to three hundred persons. It is not without interest to note that he found in Davy a very agreeable companion, but that the 'principal failing in his character is that he does not smoke.'

On the score of exposition this first series of lectures was the subject of much adverse criticism. Dalton's Cumberland accent and uncouth expressions—he was wont to refer to the elements oxygen, nitrogen and hydrogen as *these articles*—struck strangely on the ears of his audience. He gave similar courses in Edinburgh and Glasgow.

But it must be remembered that the art of exposition is not confined to the living voice; the pen plays its part, and no historical account of the subject can be regarded as complete which contains no reference to that remarkable work, the *Penny Cyclopædia*, published by Charles Knight in twenty-nine substantial volumes (1833–1846) under the auspices of the Society for the Diffusion of Useful Knowledge—the Steam Intellect Society so mercilessly lashed by Peacock in the person of the Reverend Dr. Folliott.

The work is a treasure-house of information, exact, full and detailed, on the state of science a century ago, and many of the articles are of permanent value. Augustus de Morgan contributed largely to the work, and his mathematical, logical and biographical articles may be consulted with advantage to-day. In the list of great expositors of science his name will ever take a high place. The *Cyclopædia* provides, too, a very remarkable mirror of the times as seen by its sponsors—indeed, the balance and scope of the articles go far to show the strength and weakness of the educational movement which it reflects. Thus, the article *Eudiometer* takes 4½ columns; *Logarithm*, 6 columns; *Logic*, 16 columns; Newton, 10½ columns (exclusive of long and scholarly articles under the headings *Principia*, *Fluxions*, *Commercium Epistolicum*). On the other hand, *Poetry* is disposed of in approximately the space assigned to *Logarithms*; *Beethoven* takes 3 columns (about half the space assigned to *Beet*); and *Sonata* passes unnoticed.

To return to the spoken word. No one can reflect on the names and the art of great expositors without thinking of the illustrious roll of Directors of the Laboratories of the Institution whose hospitality we enjoy to-day. Davy, Faraday, Tyndall, Dewar and Bragg—the names are an inspiration! Dwell for a moment, too, on the work and words of others who have stood at this lecture-table and spoken in this theatre—Rayleigh, Kelvin, Crookes, Huxley, Ray Lankester, Lister, Geikie . . ., truly, here, if anywhere, one can appreciate the magnitude of the task confronting one who would endeavour to describe the qualities which go to make a great expositor.

Of Sir William Bragg I can hardly trust myself to speak—his memory is so warm in the affections of all who were privileged to know him that it were an ungrateful, indeed almost an impious, task to essay any detached and detailed analysis of those qualities which made him so universally acknowledged a master of the art of the lecturer. And yet I must permit myself one reminiscence. The occasion was a meeting of one of our learned societies, and a young researcher had given an account of an investigation, in which, after the manner of youth, he had wallowed in detail, had covered the blackboard with a confusion of symbols, and had left an exhausted audience wondering what it was all about. Perfunctory applause had died away, no one seemed anxious to question the lecturer, when Sir William, who had been an interested auditor, rose, and in a five-minute talk gave a masterly analysis of the paper, cleared away all unessential details, held the attention of the audience, revealed the research as the competent piece of work it undoubtedly was, and left the author encouraged to conquer fresh fields.

Great knowledge, and knowledge ready to hand, clarity of thought and diction, power to hold an audience and, informing all, an inborn kindliness and generosity which writes him as one who loves his fellow men—are these all the qualities essential to a great expositor? At least they are among the essentials.

To estimate with any accuracy the qualities common to the characters and methods of the great expositors of science is a task far beyond the limits of a short discourse, but it may serve a useful

[1] *Vide* Peacock's *Crotchet Castle*.

purpose to discuss briefly the methods of two men, by common consent in the first rank of expositors—Thomas Henry Huxley and Michael Faraday. No two men could be more diverse in character and in intellectual equipment. Faraday's character was essentially simple and direct; Huxley's was equally direct, but far from being simple, though it is a profound error and a complete misreading of the character of the man to describe his controversial style as arrogant. Huxley, who coined the term *agnostic* to describe his philosophical position, had a mind which ranged widely over most of the solutions—or attempts at solution—of the problems of existence; his study of Hume was, and is, a classic. Faraday remained to his latest day a member of the sect of Sandemanians—a group of simple and literal Bible Christians; it has been said of him that when he opened the door of his oratory, he shut the door of his laboratory. Faraday's expositions were couched in words of exquisite simplicity, with a constant appeal to experiment, and imbued with that art which conceals art. Faraday was, above all, an experimenter, possessed of a real joy, which he was at no pains to conceal, in the result of a successful experiment. He could not pass an electroscope without flicking its disk with his silk handkerchief; and though it was a canon of his lecture creed that every assertion of a fact that could be demonstrated experimentally should be so demonstrated, it was fundamental to his own character to perform an experiment for himself; it was little use showing Faraday an experiment; however simple and obvious the demonstration, he must do it himself before he was completely satisfied.

Huxley was a capable experimenter in his own field, but it is in the nature of the case that his subjects should lend themselves less readily to popular experimental illustration than do topics taken from chemical and physical sciences, and Huxley's reputation as a great expositor is largely based on his almost unexampled power of verbal presentation. There are few survivors to-day of those whose privilege it was to hear Huxley in his prime, and the power and effect of his addresses must be gauged by reading—no bad test indeed, for many of his essays were addressed to the reading public. It were easy, and unprofitable, to multiply epithets descriptive of Huxley's style—hearken to what a nineteenth-century poet has said of the diction of a famous eighteenth-century man of letters:

> 'But read him for Style—and dismiss from your thoughts
> The crowd of compilers who copied his faults,—
> Say, where is then English so full and so clear,
> So weighty, so dignified, manly, sincere?
> So strong in expression, conviction, persuasion?
> So prompt to take colour from place and occasion?
> So widely removed from the doubtful, the tentative?
> So truly—and in the best sense—argumentative?

Each one of those carefully chosen epithets is descriptive of the style of Huxley, but the passage is an incomplete description inasmuch as it omits several important components of Huxley's style—in particular a vivacity that is never inconsistent with weightiness and true dignity.

A once-famous passage from his address to the Working Men's College on 'A Liberal Education' may serve to illustrate alike the eloquence of Huxley and the outlook of 1869:

'That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will and does with ease and pleasure all the work that as a mechanism it is capable of and whose intellect is a clear cold logic engine, with all its parts of equal strength and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamer as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself.'

Is this message of a great Victorian and great expositor quite outmoded to-day? At least, it illustrates well two characteristics common to the very different styles of Faraday and Huxley—those of clarity and sincerity.[1] On these virtues of expression Huxley was never tired of dilating. Clarity before all, for truth is best expounded and error most easily corrected when statements are made 'in such language that you can stand cross-examination on every word,' and to Huxley's downright and vigorous mind one of the most contemptible criminals at the bar of truth was the shuffler who, by the use of evasive and ambiguous language, tried to make the best for himself of both worlds.

We live to-day in a world where wireless and the cinema are more and more becoming indispensable parts of our daily life. These inventions of our age immensely increase the audience of the expositor of science, and may be wholeheartedly received as welcome aids to the living voice. But they cannot replace it; and, though the days may never return which saw an audience of 3,700 crowd into the Free Trade Hall in Manchester to hear John Tyndall discourse on *Crystalline and Molecular Forces*; which saw, in the same enlightened city, a session of ten *Science Lectures for the People* attended by more than 9,000 persons; we may be certain that expositors of the calibre of Faraday and Huxley will always command an audience eager to hear, at first hand, stories of advances in science told by those who have borne a great part therein. Mechanical lectures, like mechanical music, are well enough in their place, but they must always remain a second best.

Dr. Arnold Raestad

ALTHOUGH I am not a scientific man myself, it has fallen to my lot to be connected with certain

[1] Faraday's method of exposition is well seen in his courses of lectures to a juvenile audience on *The Various Forces of Matter*, and on *The Chemical History of a Candle*. Huxley's collected essays are easy of access, and there are few that are not stimulating and provocative. His method of exposition to a popular audience may be studied in his British Association lecture to the Operative Classes (Norwich, 1868), *A Piece of Chalk*.

aspects of the problem of the exposition of science. I have been engaged in examining the problem of how better to organise the presentation of the methods and results of science throughout the world, or, in other words, the international dissemination of science. After three or four years of preparatory work, in 1938 the League of Nations, through the International Institute of Intellectual Co-operation in Paris, appointed a committee of scientists, presided over by myself, to report on the matter. Before I tell you more about the committee and its work, it may be instructive to record very briefly the preliminary enquiries which led to the appointment of the committee.

The Assembly of the League of Nations had interested itself, in a couple of resolutions, in the use of broadcasting to promote the cause of peace and to familiarise nations with the culture of other nations. In 1936 an international convention for the use of broadcasting in the interest of peace was concluded ; and it pointed in the same direction. I had been connected with the preparation of that convention, and was considered an expert in matters of broadcasting, so when the Institute of Intellectual Co-operation wanted somebody to report on the practical steps to be taken, they asked me to consider for them what subjects they might most appropriately pick out for an organised effort. The Institute referred more particularly to the cause of peace and the work of the League, and to literature and culture generally, as promising objects for an internationally organised effort. I had to report that in my opinion neither the peace work of the League of Nations, nor the knowledge of the literature of other peoples, lent themselves very well to such a co-ordinated international effort. In each country, the radio public liked to hear their own people, and even a limited number of such people, speak their own opinions in their own way. The desire to learn more about peace and the League must come from within, and foreign literatures impress themselves on the mind of a people in response to needs, not as organised from abroad or from above. Moreover, the form cannot be distinguished usefully from substance in political and literary matter. Notoriously, the radio public in all countries is very sensitive to having a matter presented in a form which appeals to it ; so the assumption that the broadcasting services of a country, even a small one, can profitably import ready-made lectures or statements is false.

But there was another field in which these negative forces did not operate, and in which the practical broadcaster knew there was something to be done—science. The attention of the statesmen of the League had not been focused on the need to disseminate more perfectly a knowledge of science—to publicise science. Although tribute was constantly paid in the political councils to science, the true scientific spirit, etc., it had somehow been taken for granted that science was able to look after itself also in the field of its own publicisation. Now, a summary enquiry into the conditions prevalent to-day brought forth that reality is nothing like this. In most countries of Western Europe, despite the vastly increased effectiveness of the common media of information, the information at the disposal of a general public is less adequate, both as regards the progress of science and as regards topics of actuality revealing the existence of a scientific problem, than used to be the case thirty or forty years ago. The press, filling its public to the saturation point with news and political views, has only a languid interest in the results and methods of science. The documentary film and the radio have not yet, in actual practice, filled the gap. As for the radio, it has no doubt rendered great services here, for listeners are easily attracted by great scientific names or fascinated by discoveries in biology or astronomy. But generally speaking, according to fairly unanimous reports from many countries, the radio has not given what might have been expected, for a number of reasons. The great original scientists very rarely combine the qualities which make a good and attractive speaker on the radio. No single country, not even the greatest, disposes of first-rate original scientists in all branches of science, and it is well known that the conscientious scientist is hardly to be prevailed upon to speak or write about a subject he has not mastered. Apart from the normal progress of each branch of science, which can be reported, occasions calling for scientific elucidation are thrust upon the community without anybody having foreseen them ; and where is the competent scientist to explain the matter ? Before the popular science committee of a broadcasting company can find a competent scientist and persuade him to speak, or help a journalist to collect scientific data accessible to a lay mind, the actuality has passed. The matters composing the everyday information imparted to a modern public are numerous and varied ; hence the judges of actuality often are in a hectic mood. The press or film theatres are perhaps more free to be their own arbiters of actuality than is the programme director of a broadcasting company ; but their resources also are, generally speaking, more limited.

The Institute of Intellectual Co-operation, on the view of the preliminary reports thus gathered, appointed in 1938 a committee of scientists to consider the means of improving by organisational measures the way in which the results and methods of science are now presented to a general public. Members of the committee were Dr. Julian Huxley, M. Henri Laugier, Dr. Clarence C. Little, my compatriot the late Professor Sem Saeland, a Swiss, a Dutch, a Belgian scientist. All modern media of current presentation were considered in turn—lectures, press, films, exhibitions, radio. The problem was approached from the point of view of science as well as from that of society, and from the point of view of the individual scientist as well as from that of organised and collective science. The committee was unanimous in stating as its opinion that the situation called for reforms of an organisational character, that these reforms would have to be carried out, if at all, by existing scientific organisations, and that the organisation involved would have to be international in its scope and conceptions. As for the contents of the reforms, the committee, still unanimous, recommended the creation of an international centre for scientific information, the efforts of which would have two main objectives : first, a continuous recording of the progress

of science, and, second, the mobilisation, as need and demand arise, of information on any scientific point of current interest. The products delivered would, in principle, take the form of data, leaving the elaboration and the linguistic form to the journalist, the speaker, the film producer, the organiser of exhibitions, etc. Thus, for its full achievement, a more satisfactory presentation of science to a general public will require the co-operation of three agents : the original scientist or specialist working to perfection his branch and using the symbols particular to it, mostly mathematical ; the intermediary scientist qualified for grasping the symbolisms of a number of sciences and for assessing the value of theorems and proofs offered by the specialists ; and, finally, the populariser. Now and again, a specialist, and somewhat more often, an intermediary scientist, may also be a good populariser ; but the committee was unanimous in emphasising that the great and urgent need of our time in this domain is for the development of a class of intermediary scientists having its very definite rôle in the life of science, a rôle important for science and for society alike. A draft organisation was worked out in detail. Besides the central secretariat, which might be reduced to modest dimensions to start with, there would be regional representatives of the centre, and in each country, the Academy of Science or Association for the Advancement of Science or corresponding body would appoint individual scientists or groups to carry on collaboration and correspondence with the centre and its regional representatives and take initiatives. Otherwise, the initiatives would, to a great extent, come from the interested popular agencies themselves—press, radio, film theatres, etc.—as well as from the national bodies and authorities engaged in the work of spreading throughout the nation the knowledge and spirit embodied in organised science. Neither the central organisation nor its regional or local subdivisions should constitute a barrier between the press, the radio and other popular agencies and their direct access to scientists. The news, comments and publications of the new organisation should, on the contrary, be an additional help to them. The new organisation being conceived as part of the house of science itself, there is no danger that it would develop intolerance and try to exercise a sort of birth-control of scientific ideas.

In 1938 the Rockefeller Foundation had instituted an investigation into the same problems for America. Conditions in America differ to some extent from those in Europe ; for instance, greater efforts have been made to spread ' Science News ' in the press and to organise production of documentary films. On the other hand, peculiarities of the broadcasting service react unfavourably on the attitude of the public to the news about science presented there. The first Rockefeller conference on Science and the Citizen in 1938 was followed by a second one in the summer of 1939. At that time, efforts were being made by the League of Nations in collaboration with the Rockefeller Foundation to formulate a practical programme that might be put before the leading scientific bodies of the world. The war interrupted these efforts. But in the light of the experiences of this war, our aims of those days seem to me now to carry a more urgent appeal than ever.

To prepare for a lasting peace is to believe that you can have a new spiritual world. But there is no new spiritual world making for peace and progress unless it be centred in a greater proportion of willingness, and even habit, in high and low, to submit one's own judgment to the control of facts and to respect, in others, the supreme freedom to ascertain and assess facts. This submission to the control of measurement, and this respect for the truth value of any assertion, constitute, if I am not mistaken, the spirit of science. When reorganising the world, the United Nations have no more fundamental task, and no more urgent one, than to implement properly an international co-operation for an adequate presentation of the results and methods of science to publics everywhere. In this co-operation I do not propose to include nations subordinating scientific research to racial or other prejudices. Under the proposals put forth by the League of Nations Committee, the international co-operation is automatically limited to such nations as respect the freedom of scientific thought and expression. And I believe it is best so.

I know that in Great Britain the better dissemination of scientific news by the press and other popular agencies, and the establishment of a central organisation to deal with the numerous international questions which inevitably arise, have frequently been discussed. Now that the United Nations are taking stock of their opportunities and their obligations, the opportunity should be grasped to make the realisation of these purposes part and parcel of a remodelled and strengthened international co-operation.

Joseph Lauwerys

Museums and the Interpretation of Science

A FEW years ago Premier Stalin gave a toast which has become famous : ' To the flourishing of science, that science which does not segregate itself from the people . . . but is ready to serve the people and to transmit to the people all the conquests of science ; science which serves the people, not under compulsion but voluntarily, willingly.' But science cannot truly serve the people unless it be understood by them, and it cannot be understood unless those who pursue it and advance it *interpret* their findings.

The interpretation of science to the general public represents a formidable task of mass education. To tackle it, we can make use chiefly of four media of mass communication : cheap books, radio, films, and museums (in which term I include zoological and botanical gardens, aquaria, planetaria and exhibits).

Of these four media, the last has undoubtedly been the most neglected. Educationists who are concerned with adult and technical education seldom so much as mention a museum and, when they do, are obviously thinking primarily of collections of objects having historical or artistic value. On the other hand, many scientists have experimented with radio and film, but few have paid attention to the techniques of display, though some of us will remember the powerful effect of the exhibition on the ' Frustration of Science ' held in 1938.

All this reflects the sad condition of our museums —which has been too little publicised, though it was fully described in a first-rate report,[1] by Mr. S. F. Markham, M.P., presented to the Carnegie United Kingdom Trustees in 1938.

Our great national museums are second to none in the world, two hundred others are good, but the remaining six hundred are junk-shops. As for the two hundred, one begins by noting that they serve chiefly two purposes : first, to house and preserve collections, usually donated by private persons ; secondly, to serve the needs of scholars and research workers. Only in a few cases have the educational needs of ordinary citizens been taken into account and some attempt made by those in charge to interpret the meaning of their treasures to laymen. It is important to note, too, that nearly all these museums are museums of art, archæology, local history, etc. In the whole country about twenty are specially concerned with natural science, health, hygiene or medicine—the magnificent Wellcome Museum of the History of Medicine should be specially mentioned—and about another twenty are concerned with industry.

London, of course, is the most fortunate of our cities. In its Zoo an excellent start has been made : people go to see living animals and often come away with living ideas. The Science Museum is in many ways better than the Deutsches Museum in Munich, though some critics contend that the latter lays more emphasis upon interpretational as against informational effort. In the Imperial Institute one can see very pleasing and instructive exhibits on the importance and use of certain raw materials. There are other excellent places, some of which, like the Geffrye and Horniman Museums, collaborate closely with the educational system of the metropolis—for instance, by sending out exhibits and by arranging special displays to illustrate B.B.C. science broadcasts. These are only examples, but even if all the institutions available were listed it would only become more obvious that, in amount, they are grossly inadequate for the needs of nearly ten million people. After all museums are perhaps the most powerful instrument that can be used to orient a non-scientific public for more intelligent living in a scientific age, and to assure for science wide public appreciation and support.

In the whole of Britain there is not a single planetarium. This seems fantastic when one remembers how many cities in Germany and in the U.S.A. own one, and puzzling when one remembers they can be run at a profit.

It is instructive to compare this situation with that in the U.S.A., and it is natural to think first of the Buffalo Museum of Science. This wonderful institution is housed in a large and attractive building on the outskirts of the city. It is provided and maintained by the city at a cost of about £50,000 a year. In this museum an attempt is made to tell the people of the city something about the adventure of man—how he has mastered his environment and is now transforming it. In large, uncrowded halls are to be seen all kinds of magnificent dioramas and models. There are no depressing or boring cabinets of dull-coloured butterflies, no overcrowded shelves of stones and ores : just a few of the more attractive and brilliant specimens, displayed like gems against the right background, brilliantly illuminated, their meaning simply and fully explained. The ten-foot-high models showing the growth of wood from the cambium and the fertilisation of a flower are unforgettable. The exhibits, too, are integrated : one hall is devoted to the story of evolution, another to heredity, a third to man's conquest of materials, and so on. In adjoining rooms, educational films are shown and throw fresh light on the exhibits. The museum is clearly a museum of ideas and not merely of objects. The results are what one would expect : all day, every day, the place is full of children and adults. One begins to see how museums can and should be incorporated into the educational system of a city, and what a powerful instrument of adult education they might be.

Similar ideals are pursued in the Museum of Science, at Saint Paul, Minnesota—a more modest, but equally interesting place. By walking through this museum one is presented with a picture of the development of man's material civilisation. There are obvious affinities between this plan and that of the 'Outlook Tower' which Patrick Geddes set up in Edinburgh some fifty years ago—Geddes himself being probably influenced here by Le Play who had organised with remarkable success the Paris Exhibition of 1867. His plan was to educate the citizens of Edinburgh by presenting to them an encyclopedia, not in print, but in a graphic form, including not simply data, but mutually related facts. Successive floors of the Tower gave by charts, plans, photographs and sketches an integrated picture of Europe, Scotland, Edinburgh and the immediate neighbourhood.

There are many other science museums in the U.S.A. which one would describe if time allowed. They have, like our own museums, built up a vast hoard of materials and knowledge and are only beginning to put it into circulation. Many of them, however, really are attempting to apply the four great principles of display : first, to present exhibits in progressive stages of *development* ; second, to present materials so as to show their *function* ; third, to *integrate* the displays ; fourth, to make plain the *relationship* of what is shown to contemporary civilisation. These are the principles which, when successfully applied, transform museums of objects into museums of ideas.

The success of the attempts made by these progressive museums can be measured by the number of persons that visit them and by the financial support they receive. In Philadelphia, for instance, at the Academy of Natural Science, there were 18,000 visitors in 1929. Then the new policy was inaugurated and now they have 250,000. No funds have been provided by either city or state, and every penny of the money required for development has been subscribed by people not one of whom had ever taken any interest in the old museum.

In some Dominions similar experiments are being tried. A report[1] recently published de-

[1] *The Museums and Art Galleries of the British Isles*, by S. F. Markham, M.P.

[1] *Education in New Zealand Museums*, by H. C. McQueen. New Zealand Council for Educational Research, 1942.

scribed how the Carnegie Corporation in 1936 made a grant of £10,000 for the furtherance of educational work in ten museums and art galleries in New Zealand. New methods of display were worked out; the exhibits were re-arranged so as to tell stories and to present ideas; film projectors were purchased and much used; classes of children were brought from the schools into the museum for special lessons.

The results have exceeded all expectations: teachers and children are delighted and enthusiastic, the museums are crowded with visitors. As the report says: 'It has been learnt that for the adults with whom we are concerned nothing is better than a technique suited to children in their early teens.'

Let us now turn to yet another way in which museums can help in the exposition of science—to what is sometimes called the educational museum. This term is not, as a rule, applied to a museum like Ford's at Detroit, where the history of education is made to come alive, nor even to a museum specially designed to show teachers the latest pedagogic devices and ideas in operation. Usually one has in mind an institution like that at Cleveland, Ohio, which consists of a vast store of working models of all kinds, expensive scientific apparatus and machines, specimens, preserved animals and plants, diagrams, charts, lantern slides, reels of educational films, etc. These can be borrowed by the schools of the city and serve immensely to increase, at relatively low cost, the store of apparatus and equipment available to science teachers.

A variant of the same idea is found in operation at The Hague, in Holland. Here nine classes from the city schools visit the Educational Museum every day. In the museum they can see, set up and in operation, all sorts of unusual experiments difficult to carry out in a school, and rare and expensive apparatus, which otherwise they would see only as diagrams in their textbooks. There are also three or four well-equipped lecture rooms in which special lecturers deliver brilliantly illustrated lectures on science.

Incidentally, there was set up in Derbyshire, a few years ago, a Schools Museum Service which is trying to fulfil functions of this kind.

It is certain that we, in Britain, would do well to consider all these experiments and to adapt them to our own needs. In this connection let us recall the ideal held by Sanderson of Oundle—the ideal of a 'Temple of Vision.'[1] What he had in mind was an inspiring museum of universal history and of the world as a whole, giving a unified conception of the world drama in which his boys would play their part. This inspirational function was to be achieved by a selected series of exhibits, supplemented by charts of man's progress and records of his greatest deeds.

How far could such an ideal be realised? Is it altogether idle to hope that, in each of our towns and cities, there will be put up, as part of the post-war rebuilding scheme, a great Civic Centre, and that one of its most important buildings will be the Museum of Science? Here one would find, in the first place, a microcosm of the city showing its relations to its surroundings and to the state, and illustrating too, in a concrete way, the relations between industry and society. Secondly, the citizens would be given, in a series of halls, an integrated picture of the world they live in, as it has been revealed and transformed by science. Thirdly, there would be a museum of the social sciences, such as Otto Neurath established and ran with amazing success in Vienna. Fourthly, there would be halls for the display of scientific films. Fifthly, a special department would be charged with functions similar to those discharged in Cleveland or at The Hague by the educational museums. In a word, the whole museum would form an integral part of the educational system of the city and would be dedicated to adults and to children—its function being to interpret the findings of science at all levels.

A beginning is being made. Energetic workers in our museums are devoting time, enthusiasm, and patience to the realisation of objectives similar to those described. The Museums Association, which publishes the *Museums Journal*,[2] is in sympathy with these efforts and does its utmost to reinforce them. The Carnegie Corporation and the United Kingdom Trust are interested and have a definite policy. On the whole, however, few workers in museums know much about the natural sciences, and it is certain that they would welcome help and collaboration.[3] Great industrial corporations should be interested in schemes for the interpretation of science through exhibits. They are aware of the importance of relating their activities more fully to the life of the community. The films produced by such corporations—for instance, by the Petroleum Films Bureau and the Gas Association—as well as the exhibits arranged by some of them, show that they do not take an unduly narrow view of their functions or of the nature of science. They realise that their own task falls within the wider one of developing in the public a proper appreciation of science and a fuller understanding of the social implications of the domination of science in our lives.

Yet, in the end, it is to the local authorities and to the Government that we shall have to look for support. This support will not be forthcoming unless public opinion drives—which means that our citizens must first be shown the vision. No body is better fitted for the necessary task of public information than is the British Association.

Discussion

In the course of discussion at the close of the first session, reference was made to travelling museums in the U.S.A. Discussion turned mainly, however, upon the public interest in science, and scientific workers themselves did not escape criticism. It was urged that they should render more help to science teachers in schools; that the

[1] Described by H. G. Wells in the *Story of a Great Schoolmaster*. See also Appendix B by Victor Branford, entitled *A Hall of Vision* in *The Coal Crisis and the Future* (Le Play House).

[2] *The Museums Journal*, from Chaucer House, Malet Place, London, W.C. 1.

[3] As examples of some of the efforts being made, one might mention the splendid displays often arranged by the National Museum of Wales (e.g. 'Tin Through the Ages'). The Leicester and the Geffrye Museums should also be mentioned.

language of science should be simplified for public understanding ; that there were various groups, as in the services and elsewhere, ready to receive instruction in science if they could get it. The interest in science evinced by working men's societies half a century ago was recalled : other forms of mental recreation would seem to have diminished this interest. Russian experience in these fields, especially that of museums, was briefly described by one speaker.

RADIO AND CINEMA

Saturday, March 20 : Afternoon Session

Address by
Sir Allan Powell, C.B.E., D.L.
Chairman

The subject which we are to discuss to-day is described as Radio and Cinema. I must confine myself for the most part to radio broadcasting and some of its various ramifications and possibilities.

It will be obvious to everyone interested in science that enormous strides in the technique of certain branches of radio work have been made during the last 3½ years, progress which could not possibly have taken place so rapidly but for the stern necessity of war. We are not permitted to go into the details of war-time developments, nor to consider what effect they may have on post-war broadcasting or television, except perhaps in a very general way. Nevertheless, I must stress that much water has flowed under the bridge since broadcasting became an instrument of war. When it is again taken up on a peace-time basis the fullest consideration will have to be given to the progress which has been made in other fields, and the use which can be made of it to further this particular branch of radio work. Without giving away any secrets we can at least consider what subjects will immediately present themselves for consideration on the cessation of hostilities—or, of course, before—in so far as time and ways and means are available.

Before September 1939 the service given by the B.B.C. could be divided into three semi-distinct categories. There was first of all the sound service, which provided programmes of very different types for listeners in this country ; then there was the infant service of television, involving a far more advanced technique than anything necessary for purely sound broadcasting ; finally there was the overseas or Empire service, similar in many ways to the home service but necessitating the use of short waves, which depend on ionospheric reflection for transmission across the world. True that at the time of Munich we began to talk quietly in four languages, but it is a key to war-time development that in four years these four languages have become nearly fifty. These latter services involve weighty scientific problems : problems for the solution of which the work of scientists all over the world is being constantly watched in the hope of solving the inherent difficulties of transmission by a medium whose vagaries and changes are only partly understood.

Before the war the B.B.C. included in its organisation a radio research department which was steadily growing, and its activities ranged from the scientific study of the acoustics of halls and studios to the study of the ionosphere and the application of the work of scientists in elucidating the practical problems of conveying programme material to all parts of the world at all times of the day and seasons of the year. On the outbreak of war some of the work had to be abandoned, and the activities of the staff left to us were of necessity turned to the immediate problems of conducting a broadcasting service for home and overseas to fit the special necessities and restrictions of war. These I cannot go into, but were I able to do so it would explain immediately why it has not been possible to continue with many of the unsolved problems which we had on hand in peace time.

Let us consider now what these problems are, and let us turn to the oldest part of the service first, namely sound broadcasting in this country. We have never been satisfied with the reproduction which was obtainable in the homes of listeners, even assuming the excellence of the receiver. We have never thought that the acoustical treatment of studios or concert halls had been satisfactorily solved on a scientific basis. We think that great strides are possible, for example, in giving a feeling of depth to an orchestra, or in the more realistic portraying of scenes in radio drama. Nor have we been satisfied with the coverage, or the number of programmes which it has been possible to produce. Many people may think that sound broadcasting by itself has no great future and that it must very soon be supplemented by television, but it is necessary to bear in mind that the addition of vision to a broadcast programme does not in any way obviate the necessity of maintaining and improving the reproduction of sound. Then again, what about television ? It seems obvious that television must be the most outstanding direction in which the art of radio will progress. We had made before the war what may justifiably be called a first-class beginning, which was sufficient to convince almost everyone that the addition of vision to sound was merely a matter of time. Whether or not every programme will be accompanied by vision is another matter. When we come to post-war activities it is certain that many programmes will be considered incomplete without it. Progress as the result of scientific research is inevitable—it is the speed at which it may come, governed as it is by several factors, including finance, which makes one hesitate. Modern science has very greatly reduced the period of achievement in these days compared with a generation ago. I will venture on the forecast that in less than twenty years the great majority of listeners will be equipped by one means or another with apparatus which will combine seeing and hearing.

Television, therefore, must be one of the principal preoccupations of the broadcasting authority in any post-war problem. The question what television, in the scientific sense, is another matter; whether it will be the television which we knew in 1939 or whether it will be a much more advanced form or whether it will be the two together, is a matter on which I cannot attempt to prophesy, but I can say that such problems are already receiving the attention of the many people concerned.

What of the future of long-distance broadcasting on short wavelengths? Can we look upon this as an established service in which only minor improvements are possible, or must we say that the unsolved difficulties will prevent its development on any considerable scale? Here I think we can be more definite. The linking together by wireless of various countries in the world must be a factor of the greatest importance in settling the gigantic problems which are so much on everyone's lips and will need every possible aid to ensure speedy solutions. Some sceptics might ask what good has long-distance broadcasting done in the past; has it not in fact spread false doctrines and militated against the development of true civilisation? I think my answer would be that if it has done so it is merely a proof that it can act in the opposite direction, and do far more good in the future than any possible harm it may have done in the past. We in this country at any rate have held fast to the view that this great modern invention is for the service of man for constructive purposes, and I believe it has been shown to the world that there has been nothing but loss to those who have sought to prostitute it to base uses. If we are at last to reach the age in which the same standards of conduct and responsibility shall be observed among nations and their governments as those followed by individual citizens in enlightened States, then radio has a great part to play and the conduct of British broadcasting during the war will appear as a valuable contribution to a universal plan.

As to whether scientific development has taken long-distance broadcasting as far as it can go, I think the answer is emphatically no. There are many types of broadcast programme which it is not practicable to transmit on short waves at the present time, because of the distortion (due to what I have called the vagaries of the ionosphere) being too great to ensure the true reproduction of what the producer is striving to register. But surely this can be got over. Perhaps it will mean in the future a tendency towards distant reception at a central receiving station, embodying in its design elaborate and highly scientific new principles, while the listener will receive the programme relayed to him by some local method of distribution—either by wireless or wires. Whether or not this will be the case, there is little doubt that gradually the ionosphere will, so to speak, be tamed and means will be found to use it more effectively as a means of transmission in almost all its moods.

In its own actual broadcasts both to home and overseas listeners the B.B.C. has played its part in close co-operation with the learned societies and outstanding scientists in bringing home scientific truths to the listener in popular and understandable language. Noteworthy results were seen in the series of talks on the biological sciences, 'Man's Place in Nature' and 'Reshaping Man's Heritage.' Later series of talks will, it is hoped, deal with the physical sciences and with engineering. A large proportion of the spontaneous comments paid tribute to the series as a whole, and the audience, if limited at the outset, was faithful and enthusiastic and growing. The discussion groups in particular showed great interest in the series, and it was reported that considerable wonder and excitement were aroused in the groups, showing that at least a proportion of the subject matter was new to listeners.

Many other broadcasts gave the listener some knowledge of the immense amount of work done to harness scientific research to the war effort, and the fact that much of this work must remain secret for a time does not prevent its having a real value as a subject for broadcasting.

Again, broadcasting to farmers has a great responsibility in describing agricultural research and giving means for the everyday application of scientific methods to the farm. Farming, too, of its nature, had hitherto lacked the advantages of easy intercourse and the chance of discussion of these problems against the universal background of knowledge. For ten years now it has been B.B.C. policy to present continually to some 400,000 farmers, the largest single industry in Great Britain, such discussion of scientific work.

Then too there is the very valuable work done by B.B.C. Schools broadcasts. Secondary schools with specialist science teachers and well-equipped laboratories do not look to broadcasting for help in their studies, though they are interested in broadcasts on the social application of science and its history, and now and again like to have a talk from a well-known scientist. The late Sir William Bragg once dramatised for secondary schools an early session of the Royal Society, using the official record as the basis for a lively exchange on Authority versus Experiment.

The main school audience, however, is the elementary school, generally without specialist teachers and laboratory equipment. There were inherent limitations in broadcasting as a medium of instruction, though before the war these were to some extent surmounted by the provision of children's pamphlets with diagrams, photographs and directions for simple experiments. After the war televised broadcast lessons in science may carry on what such supplemented sound broadcasts began. Broadcasting can make with success a real contribution to the schools by providing some simple exercises in scientific methods and habits of thought, telling stories of the work of earlier scientists when the background of knowledge was little wider than the child's own. It can take him along the paths of discovery and heighten his sense of wonder. It can help the non-specialist teacher to satisfy the child's curiosity about himself and the natural world. Broadcasts on reproduction and growth, on the story of evolution and on the world of sound, have been perhaps the most successful examples of the technique of the B.B.C. Schools Department.

Time does not permit of my making more than a brief reference to the cinema. Radio and the cinema have many common problems and will have more in common as television develops.

In their relation one to another we meet one of the problems of television. The reproduction of, shall we say, actuality programmes of topical interest in a cinema must surely have a great future, to take only one possibility. If this is to be done effectively the reproduction of a large picture which can be clearly seen by an audience of perhaps 2,000 people sets a problem for the television engineer which has certainly not so far been solved, but is certainly not insoluble. This aspect is one which must never be lost sight of in designing a system of television to meet all needs. Then again, what prospect is there of being able to send these pictures to distant places outside the confines of our own country? Up to now this has been achieved on a very large scale by the interchange of films. What are the prospects of transmitting a picture of an event happening in this country, while it is still in progress, to some place thousands of miles away? We must admit that we do not know how to do this, nor can we see at the moment how it is going to be done effectively. Nevertheless when I was in America just before the outbreak of war it was claimed that pictures of a sort from our television station in this country, which then was only serving an average area of fifty miles from the station, were received in the middle of the United States. To make them of practical value we may have to wait for some new discovery in connection with ionospheric transmission, or it may be achieved perhaps by means of some form of wireless transmission hitherto hardly thought of, or even perhaps by some new transatlantic cable. I am convinced, however, that a means of solving this difficulty—at present apparently insuperable—will be found. It is claimed that people are more impressed by what they see than by what they hear. However that may be, the cinema has dealt with the problem of combining sound with sight as broadcasting is facing the reverse problem. The cinema like the radio should play its part in full measure in combining entertainment with information and instruction, and the question of the right balance between the various services it can provide affects both, though radio, as conducted in our country, is free from the necessity of keeping at least one eye wide open upon financial results.

Realism through the documentary film has had its advances and its set-backs—it has been gaining ground through such excellent work as that done for the Ministry of Information and elsewhere under war conditions. It may well be that the new generation may desire more of actuality, of real things and live people to be shown to them by the cinema, and to hear more by way of commentary on events following that noteworthy development, the March of Time. That, if it occurs in thousands of cinemas across the world, will raise, as it has been raised with sound broadcasting, the question of the proper limits of freedom of speech. If the radio speaks to more persons at any one moment, it has been estimated that in eight weeks the moving picture audiences equal in number the total population of the globe.

There are obviously great possibilities in the cinema, as there are in radio, for bringing nations nearer to one another in general, and for advancing the purposes of the cultural and scientific world in particular.

In all these matters those concerned require the help of science to the fullest degree, as indeed it is urgently required in the whole of the vast field of reconstruction and development in the post-war world. It is indeed not too much to hope that science, which is universal and has no national boundaries, and scientists throughout the world with their work for mankind as a whole, may, in radio communication as in many other directions, lead the way to international co-operation in the post-war world.

Sir Robert Watson Watt, C.B., F.R.S.

The Four Freedoms of the Listener

THE use of the broadcasting system as a means for widening the public understanding of science poses technical problems of presentation and of distribution of programme material. Present standards of education and present traditions of thought are such that the average citizen listening to a programme about science is in general a reluctant, at worst a hostile, and at best an unawakened listener. To hold and to stimulate the interest of such a listener, the broadcaster must ensure conditions specially favourable to sympathy and undivided attention.

The listener will, I suggest, become a willing and interested listener only if he enjoys each of the Four Freedoms of the Listener. These four freedoms are Freedom of Choice, Freedom from Interference, Freedom from Distortion and Freedom from Distraction. The first three are primarily governed by radio-technical considerations, the last by the no less difficult technique of preparation and presentation of broadcast material.

In existing conditions Freedom of Choice is inadequate. Very few listeners will submit cheerfully to instruction or 'improvement' unless they are sustained by that consciousness of right which rests on the knowledge that they are of their own free will rejecting variety or vaudeville, or variations on a theme of Handel, in favour of the spoken word. This exercise of free will is insufficiently wide so long as there are only two effective alternatives, and I believe that the simultaneous availability of six separate programmes, clearly defined in character, complementary and contrasting, is essential to balanced broadcasting. I propose to mention later some technical factors in the provision of six programme channels.

Freedom from Interference involves the elimination, from reception, of undesired noises produced by radio communications other than those carrying the desired programme, by the atmospherics radiated from more or less distant thunderstorms, by the noises, which the Americans graphically call 'man-made static,' radiated from electrical machinery, gas-discharge lighting systems and the like and by that irritating background of hiss and scratch which is the regrettable label of the now-too-frequent recorded programme. Some of the interference from other programmes may be due to 'side band splash' from adjacent channels; some may be due to such scientifically interesting but aesthetically irritating incidents of propagation as are typified by the 'Luxemburg effect.' Man-made static will ultimately be suppressed by man-made statute, but the process may be slow.

Freedom from Distortion requires improvement

in fidelity of reproduction of the sounds to be transmitted. Distortion occurs in the transmitting equipment, in the medium of propagation and in the receiving and reproducing equipment. Of these sources the most serious offender is the receiver, the transmitter does not make a very large contribution to the total distortion. Distortion in the medium is usually part of the complex of disturbing incidents due to the passage of some of the reserved energy by way of the ionosphere. This distortion, like that produced in the circuits used, often takes the form of uneven treatment of different frequencies ; there is, however, another form of distortion in which different amplitudes at the same frequency are reproduced in a changed ratio. This latter form may also arise in the medium or in the circuits, but in general the receiver-reproducer is the main seat of amplitude distortion.

The great common enemy of the three freedoms thus briefly outlined is the particular band of radio frequencies allotted to broadcasting. The wavelengths between 200 and 2000 metres were chosen to carry the broadcasting services for a variety of reasons, historical, technical, and economic. It is singularly unfortunate, from the standpoint of the freedoms, that the wavelengths which give a large service area by day because of the low attenuation of the ' ground ray ' are copiously returned from the ionosphere by night—and ' radio night ' in the ionosphere lasts for a large part of the winter day. The ionospherically reflected rays suffer from amplitude and frequency distortion, and interfere with one another and with the ground ray, causing fading. Broadcast radiation on those frequencies which give a large service area by day thus almost inescapably produce a technically and aesthetically unsatisfactory service in the hours of and near darkness—which include a very substantial fraction of effective listening hours. For similar reasons these frequencies are also subject to considerable atmospheric disturbance and to interferences by signals in adjacent or in very high power channels even though these signals may be of very distant origin. There are technical devices available to mitigate the worst effects of fading, but they fall far short of satisfying the two technical freedoms. Moreover the frequencies in these channels are so low that very few independent channels can be found in this part of the radio spectrum, so that the first freedom, that of choice, cannot be satisfied.

It is for such reasons that it is suggested that at least a drastic change in the choice of frequencies used, to eliminate the distortions and interferences which result from the reception of waves returned from the ionosphere, should be made for programmes in which high fidelity reproduction, whether for aesthetic satisfaction or for the holding of concentrated intellectual attention, is required. There is a strong case for providing a generous service of programmes of this character which is not ' broadcast ' generally but which is distributed by what I may call an underground ' pipe ' system. The listener would, in a large proportion of cases, take his programmes direct from the pipe-line ; less favourably situated listeners would receive from local re-transmitters working on wavelengths so short as to suffer no reflection from the ionosphere.

The fourth freedom, that from distraction, overlaps the others, since the radio-technical troubles outlined have a very high distraction value. But, as I have already said, freedom from distraction cannot be assured without close adherence to the difficult and exacting laws of preparation and presentation of broadcast programme material. The listener to talks which carry, in his mind, the forbidding labels educational, instructional or cultural is vaguely distrustful, and is acutely sensitive to defects in the method of appeal to his mind. He is suspicious of over-simplification and intolerant of over-elaboration. He is impatient of pedantry and resentful of facetiousness. He does not want ' the truth, the whole truth and nothing but the truth.' He will regard the presentation of ' the whole truth,' in the form of a nicely balanced argument, with all the qualifications necessary to precision, as ' hedging.' He will regard ' nothing but the truth ' as desiccated and uninspiring, but he will very rightly reject the false embroideries of artificiality, of quips and conceits and of any dramatisation save the most discreet and most moderate. And he will be no more grateful for a too easy camaraderie than for a blatant *de-haut-en-bas*-ism.

There is scope for high skill in the presentation of science to the citizen by way of the broadcast medium ; the goal is worthy and attainable, but the way is no easy one.

G. Ivan Smith

IT is the responsibility of a broadcasting system to present talks and features on such a wide range of subjects as to include current affairs, theology, the humanities, and science. In no case are they directed to experts on the subject, because other media are available to do this more effectively. The value of broadcasting lies in its power to reach all sections of the community and to interpret the expert to the less expert. To facilitate this interpretation a broadcasting system has a number of producers who have studied their audience and its listening conditions, and evolved general rules on broadcasting technique designed to hold the attention of a mixed audience.

It would be impossible to detail these rules—so much depends on the subject and the speaker. But quoting some which are very general will indicate the functions of the Talks Producer. He has to see that the subject matter of the talk is related to the everyday affairs of the general listener. He tries to arrange the subject matter so that the ideas are unfolded in simple and natural sequence, wherever possible in chronological sequence, taking the listener forward step by step from the simplest base to the broadest aspect. The producer asks the speaker to avoid figures and technical terms wherever possible, but when they must be used he asks him to explain them by giving simple illustrations. It is also his job to see that the script is written and spoken with conversational emphasis, remembering that the listener is very close to his loudspeaker and prefers to be ' spoken to ' rather than ' lectured at.'

The producer is not there to teach elocution or to see that the talk is given in any standardised manner of delivery. On the contrary, he wants natural speech in the tone of voice and with the

same phrases that would be used when speaking normally to friends. A producer of talks on science has special difficulties. The first is that the bigger proportion of the general audience consists of people who have had no training in science. I believe that they tend to fight shy of any programme labelled ' science talk.' It is also my belief that adults in this audience more readily listen to broadcasts on, say, philosophy, theology, and the arts because man thinks about the humanities instinctively. There is an appeal to emotional interests. I think that such an appeal must be used to introduce science to the untrained listener. He can be made ' to feel,' ' to sense ' the close relation of science to his own personality by programmes on the chemistry of the body, the soil, plants or the applied physics which create his material environment. I am sure that this is the most important approach—to stress the relationship of science to society. For too long people have regarded it as a separate thing, as a weapon in the hands of a few gifted men.

It may seem paradoxical to recommend the teaching of scientific principle by this means, but it is purely a means of introduction. Once a listener is interested then principles of science can certainly be emphasised. This is best illustrated by the special production methods used by the B.B.C. science broadcasts to schools. In a series about astronomy, an observer, who travelled through space in an imaginary rocket ship, described what he saw ; the earth from outside, the geography of the moon, the outer planets, and a comet's orbit which he followed. Here was something which caught the imagination of children. Nevertheless, the children were told how to tell longitude and latitude by the sun and the stars. They were given the names of the planets and learnt about the energy of the sun. The whole story was studded with facts which, I am convinced, were understood and remembered more easily than if they had been precisely stated without any imaginative setting.

For anybody studying broadcasting as a means of popular science exposition it is profitable to examine the methods used in schools broadcasts because so many of them might be applied for the whole adult audience. The producer uses what he calls the principle of actuality, which he states as follows : ' Theories should be the answer to a felt want, should be applied to solution of real problems, and should be placed in their social and historical setting as a tool socially created and socially used.'

Here are illustrations of how the principle of actuality has been applied to science broadcasts for schools.

(1) Science in social practice. Programmes on ' Sources of Power,' ' Electricity in the Service of Man,' and so on.

(2) Science in personal use, e.g. the series on ' Food and Health ' and on ' Heat in the Home.'

(3) Answering natural curiosity about how things happen. There was a series of talks on ' Using Your Senses ' ; one each on eyes, ears, and fingers, and then the last showed how measuring instruments enable us to use these senses to the best advantage for the purposes of science.

One series called ' Notes and Noises ' used the resources of radio to provide demonstrations in sound which were beyond the scope of the school science laboratory. The programme described how sound is carried, its speed and quality, ways of making sounds, and then how the knowledge of sound is used in war (echo sounding, the hydrophone, and so on). In these programmes the producer has related the subject to everyday experience and illustrated by mechanical reality. The dramatic technique has been widely used to present the growth of scientific ideas in their historical setting.

It is evident that by using these methods you can overcome the first difficulty—that of broadcasting to an audience of people who have had no training in science.

The second difficulty I have encountered is that scientists as a group are not natural broadcasters. Quite frequently they are used to lecturing to students or to learned societies, and they tend to use the same manner in addressing the microphone. Usually this is a fault quickly and easily put right. But a much harder thing to do is to convince some speakers that their facts need a similar kind of special presentation for an adult audience as is given in broadcasts to schools — simple illustrations, actualities, in an imaginative setting. They sometimes admit the need of this broadcasting technique as an approach to children and yet deny it to the adult listeners, the majority of whom have no science training. To these adult listeners the need for simple presentation is no less than for children. In fact the adult has more distracting interests to take him from listening to a broadcast talk which he does not understand. Additionally he is not hearing the talk in an organised group like a school class in which doubts and misunderstandings can be cleared up by discussion after the broadcast. The fact is that you must reach the adult listener's understanding immediately. There can be no going back over misunderstood statements.

Some scripts contain technical terms and phrases not known to many people in the audience, but the speakers will not attempt any illustration because in their view it cannot be done with strict accuracy. Linked with this is their distrust of any attempt at popularisation. I have observed a marked tendency on the part of senior scientists to discredit any of their colleagues who attempt it. I have actually been told that popular expositors are dangerous because they use half-truths to catch the public imagination.

While this respect of facts is very desirable, such an approach to popularisation cannot be reconciled with the community's ignorance of even elementary principles of science. That is the fault of inadequate school education, and the broadcast executive deplores it as much as the scientist. I think we must accept that it is impossible to hold the interest of such an audience in a talk on a specialised subject and at the same time present that talk with such even balance of all factors that the sternest critic could find nothing to criticise. But the fact that some scientists have attempted to make broadcasts on a variety of subjects in a series on science has raised a charge that broadcasting systems present their talks on science by people who are ' Jack-of-all-trades, master of none.' It think this is sometimes true, and, frankly, I think it happens because scientists

have evaded their responsibility of interpreting the results of modern research to a relatively ignorant public. In doing this they have left the field wide open for people less qualified to speak on specialised subjects. But I would here pay tribute to many eminent scientists who have done great work in the field of popularisation and are at the present time co-operating with the B.B.C. producers in every way.

The producer must ensure the speaker's prestige by making him talk to be understood. A parallel responsibility he owes to scientists is to preserve their prestige by selecting from the best broadcasters only the best authorities on their subjects. In planning a series of talks he should not ask an eminent scientist to contribute with others who will not do justice to the subject, or in a series which does not cover all of the important aspects of the subject. In this matter the broadcasters have frequently been guided by scientific bodies, and I know we are indebted to them for valuable help.

An illustration of this is in a series of talks broadcast in the B.B.C.'s Empire Service last year. Two broadcasting officers met the Science Committee of the British Council, whose chairman was the late Sir William Bragg. Together they planned the subjects. The scientists outlined the material they wished to cover and the broadcasters suggested ways and means of doing it. The Science Committee made certain that the producers had the most highly qualified contributors and the producers, for their part, gave as much time as possible to adapting the material and encouraging natural speech at the microphone. Again, when the B.B.C. Home Service was planning talks on science, its producers had consultations with the Natural History Museum and workers in various fields of biological research. From this it was determined to attempt a very simple series deriving from T. H. Huxley's great popularisation of the story of Evolution. 'Man's Place in Nature' was the title of the course. It was planned by Prof. D. M. S. Watson, F.R.S., who also contributed a number of talks himself.

When I have worked with advisers elsewhere they recommended subjects, helped plan the course, suggested names of possible speakers, commented on my nominations, and corrected errors of emphasis or fact in the finished script. But they have always worked on the understanding that the broadcaster shall have final judgment on selection of speaker and method of production provided facts and emphasis are correct. It has only been successful when the advisers were enthusiastic about popularisation. With respect I would say that I have found the enthusiasts among younger scientists.

The B.B.C. is broadcasting not only to thousands of listeners in schools, millions in Britain, but also to many more millions in overseas countries. And if we remember this fact when reviewing the lists of science talks it has done, however far short they fall of your hopes, one must conclude that your Corporation is doing a work that is unexampled in the world. I say that as an independent observer from another country who has had the privilege of working behind the scenes at the B.B.C. I am not trying to suggest that the B.B.C. is satisfied that it is giving the best possible service in the exposition of science. The producers are the first to admit this. It will never be a really good service until you, the scientists, and we, the broadcasters, begin to understand much better the urgent need for popularisation and the ways and means of getting the principles of science over to an untrained audience. In my experience this conference is the first time I have heard any detailed consideration given to the whole question. It is a very significant conference, and a great deal more thought should be given to popularisation if you are to develop the public appreciation you deserve, which is essential if you are to have the interest, the money and the organised application of research which are vital to your work.

As I see it the B.B.C. is in a unique position to help in creating an appreciation of science, because it is a public utility without commercial competition. (There will probably be many more such public utilities working in different fields here in the future.) Many countries have broadcasting services which depend on commercial sponsorship for the type and quality of their programmes. In many cases it has produced outstanding programmes of community value, but generally speaking I think it has caused these commercial systems to concentrate on pure entertainment and neglect the primary job of educating for citizenship. As a monopoly the B.B.C. has an immense responsibility to interest all sections of its vast audience, but it is free to do this at a high standard. It can develop from its already considerable achievements and present science to the citizen as an example to the world—if the double responsibility is accepted : (1) of the Corporation to ensure high standards and the guardianship of its selected speaker's integrity ; (2) of the scientist to take infinite pains to interpret himself to his fellow-citizens in language that can at once arrest their attention and be easily intelligible.

Dr. C. D. Darlington, F.R.S.

To consider what relation science should bear to the radio we must first agree on what we mean by science to-day. Scientists used to consider that science was their private concern, just as landlords considered land was their private concern. But the world is much less private to-day, and that is particularly true of science. The scope and purpose of science have grown as its power has increased, and we are now compelled to fit it with a larger size of definition. Science, as we now have it, is nothing less than the arrangement of knowledge for the benefit of mankind. That view is based not on a generosity of sentiment but rather on an economy of sentiment, on the good old principle of Occam that you should not waste your ideas, or anyone else's ideas either.

In the past the arrangement of knowledge alone has been our business. Other people, non-scientific people, commercial and political people, have concerned themselves with the benefit of mankind. But for some time a crisis has been evident on this side of the undertaking. Mankind has not received the benefits from science that we might have expected—quite the reverse. And since a bad workman always blames his tools, science has been freely blamed for the results of its misuse by others.

The man of science and the man of government

are each largely ignorant of the other's job. In recent years the scientist has shown a laudable amendment. He has begun to take an interest in politics and has made some progress with his lessons. But what of the other side? The picture is not hopeful.

For a hundred years now science has been transforming the world, and for a hundred years governments have been painfully stumbling behind. The path they tread is what they always call progress. It is actually a path on which they get further and further behind the conditions they are trying to catch up with. Of those who govern us, between 90 and 100 per cent. are ignorant of the method and meaning of science. They have been educated in a pre-scientific age. Our educational system instead of integrating the future with the past has bent all its efforts to their separation, to dividing science from the humanities. That fatal separation is evident in many countries, but in this country it has been carried to the limit.

It is in this situation, which I regard as critical, that we must turn to the radio and ask ourselves whether it provides a means of national readjustment. We are fortunate in having an organisation, the B.B.C., which can be used for the furtherance of a national interest. It may even not be indifferent to the benefit of mankind as a whole. It certainly seems to be taking a great interest in mankind just now. Is it, however, organised at present in such a way as to understand this crisis and its remedy?

The Board of Governors of the B.B.C. has been carefully selected. It represents some of the most respectable interests in the country. The bar, the press, the Foreign Office, social welfare and administration, and even banking appear to be represented. But radio was not, I think, invented by a barrister or even by a banker. It is a scientific invention, and of necessity its scientific and technical staffs are numerous and capable. Its internal scientific problems are vast and urgent. Yet we notice that by some oversight no man of science has been found qualified to take his place amongst the seven members of the Board. That is a difficulty which prudent enquiry might have been able to overcome some time ago. Now it must be overcome speedily. We must have knowledge and understanding at the top if we are not to waste our time lower down. That is the first step.

The next step is to establish a science committee which shall prepare, co-ordinate and direct a science policy in broadcasting. Such a committee would not spend its time in squabbles between rival sects. It would have a broadcasting expert as chairman. It would have an important piece of work about which I think its members would have no difficulty in agreeing. What would this work be?

First, they would have to think out how to raise the scientific interest and understanding of the public. They would address themselves to the educable fraction of listeners, a fraction which would be gradually increased, perhaps from 5 to 25 per cent. I have evidence that, owing to better education, this fraction is higher in Sweden and in the Soviet Union than in this country, and a science committee would undoubtedly have to make enquiries as to methods and results overseas.

A committee would then arrange programmes in different classes according to technique and emphasis. The first group would be *practical*. It would cover industry and housing, agriculture and food, medicine and health, education and social habits. It would cover equally short-range applications and long-range effects. It would be directed partly to special groups such as housewives, mechanics, engineers, and farmers. And of course schools programmes would be carried to a more advanced standard than now. No one yet knows what science can usefully be taught in schools, and there is no better means of experiment than the radio.

A second group would be *personal*. It would consist of the narrative and biography of discovery. It would cover the whole field of history and not just Britain's three radio heroes—Newton, Darwin and Faraday. It would illustrate the technical and social relations of scientific discovery both to-day and in former times. It would illustrate also the detective interest of discovery. And it might tend to make history appear, not as a record of romantic destruction, but as a process of scientific creation.

The third group would be *topical*. It would consist of science news, book reviews, notes on congresses or individuals, scientific commentaries on national or international events. For this purpose corresponding organisations in different countries would be glad to exchange information as a means of cultural propaganda.

There would be no special discussion of the principles of science, its experimental and statistical methods or its long chains of inference. Rather the aim would be to illustrate these processes under the first three headings. And above all the unification of knowledge by science, its opposition to mysticism, and its interest for humanity and its international character would be allowed to appear accidentally as occasion offered. Indeed information would be detailed merely to bring out these connections.

Another task of organisation would be to arrange discussions. The discussions would be controversial as well as non-controversial. They would be between representatives of different branches of science, between scientists and non-scientists who are applying their discoveries—or in some cases failing to do so. A farmer could meet a soil scientist, a medical man could meet a geneticist, a population expert could meet, say, a politician. Indeed, almost all sections of the community could get to know one another in this way.

Yet another task would be the co-ordination of overseas and home broadcasts of science. At present there is no co-ordination. A recent series of broadcasts on science was perhaps the best organised ever given. It was presided over by the late Sir William Bragg. It was broadcast overseas. No one in England heard it. A dozen experts in their several fields covering almost the whole range of science had prepared an integrated account of their work. They were busy men, all engaged on war work. Why should their efforts have been devoted to enlightening only a fraction of their possible audience? Similarly broadcasts have been sent to America of conferences in England which could not be heard in England.

Why are English events assumed to be of greater interest to the American public than to ours? Is it perhaps thought dangerous to overstimulate the patient population of these islands? These questions are important both for the broadcaster and for the listener.

Take the broadcaster first. The work of scientific broadcasting is pioneer work. It demands a powerful and concentrated effort—an effort of simplifying on one side and of integrating on the other. An expert who wishes to produce an effective result would always do well to devote a month's thought to a twenty-minutes broadcast. The result may well be worth this effort, and a scientific management would encourage it. But is a busy man going to make this effort if he knows that the people at home whom he is most concerned with cannot hear him?

Then for the listener. We may be told that the home programme is already fully occupied. What is it occupied with? We are not concerned with the Schools programme, which is excellent within its unduly narrow limits. The home programme includes seven hours of religious broadcasting, and ten to thirty minutes of scientific, per week. The Forces programme includes 1¼ hour of religion and no science whatever. No one connected with these programmes has apparently been able to discover any relation between science and war that could interest the forces. Or is it held that scientific thinking of unofficial origin would impair military discipline? I do not know. But whatever the obstacle to scientific broadcasting may be, it is not time.

It seems rather that religion is preferred to science because the religious broadcasts have slightly more listeners than the scientific. There is, however, another factor to be considered. Religious listeners are largely those with the most leisure on their hands. They will on the average listen to twenty or thirty times as much as the scientific listeners, who, I suggest, will usually be found to have plenty to do with their time. The views of the two groups are therefore of importance inversely proportionate to their relative weight in the B.B.C.'s listening canvass. Evidence on this point would be of some value in apportioning times to programmes.

Our second problem in dealing with science and the radio is the scientist. A great part of his training is devoted to exorcising what Bacon called the Idols of the Market Place. Now we are asking him to turn back on his path and once more pay his oblations to them. For him it is an effort as well as a sacrifice. But it is not, as he sometimes imagines, a heresy or a crime. The situation has changed since Bacon's time. In translation from one language to another something is usually said to be lost. But in translation from scientific to popular speech something is to be gained not only for the listener—that is obvious—but also for the translator. For simplification we have to be able to see the wood as well as the trees, a task which is useful in science in proportion to its difficulty.

We must therefore learn to speak the other fellow's language as well as our own. We must be willing to bear in mind that the 'vessel containing approximately 500 c.c.' is also the pint pot and should be called the pint pot if its meaning is clearer to the other man in that rude vernacular.

I believe many scientists will be found willing to submit to this discipline of simplicity. But how is the B.B.C. to find them? They must be men who can write simply, speak clearly, and show without shame their energy, their adaptability and their enthusiasm. There is one and only one bountiful source of these qualities—that is in youth. The B.B.C. gets hold of youth with its 'Under-twenty' sessions. But oddly enough the 'Over-twenties' are overlooked. A producer once asked me if he might announce that I was a young man, 'because,' he said, 'the public seems to think that most of our speakers are rather old.' The public, it seems, is wise enough for that. The remedy is for the B.B.C.'s science organisers to make their contacts with possible young speakers directly at scientific meetings, such as those of the British Association and the Association of Scientific Workers.

These are the plain outlines of the problem and of its solution as they appear to me. There is an immense amount of work waiting to be done both by the B.B.C. and by ourselves. There is an immense amount to be learnt both by the B.B.C. and by ourselves before we can do this work. And there are immense obstacles of habit and belief to be overcome before even the learning can begin. But I think that we must face these tasks. If we do not face them we shall not be able to play our proper part in this country in the years to come. Nor will this country be able to play its proper part in the world as a whole.

Dr. D. McClean

I REGARD myself as being here to represent the views of the Association of Scientific Workers on this question. My personal opinions would not have any particular importance, but I suggest that the considered views of a committee of the Association of Scientific Workers do deserve serious consideration.

If we are to avoid mistakes in social planning both during and after the war, it is important that the general public be helped to understand how evidence for or against any course of action may be rationally examined. That is to say, there should be developed a widespread education in the scientific method of attack on any problem and a familiarity with the general method of science. I realise that in its ordinary programmes the radio cannot 'teach' in the sense of giving formal education, but it can awaken and maintain interest in an attitude towards society and towards the conquest of our environment.

There is no need, now, to illustrate the effectiveness of science and scientific method. Too many people, however, are conscious only of this effectiveness as applied to methods of destruction. Yet our present civilisation is undoubtedly formed on and maintained by the great recent developments of science and technology which have been used for creative ends. It is imperative that the general public should be infused with the knowledge that the body of science and its method of development are instruments that can be controlled and utilised to whatever ends a community may choose. In order that these ends may be aimed at the increase of happiness of an

enlightened community it is necessary that the creative potentialities of science in the broadest sense be brought vividly into the consciousness of all citizens. This may be done by intelligent reference to the development of science and its consequences in the past and present, and by rational discussion of problems of social significance which still require solution.

We consider it of fundamental importance for the survival and development of our civilisation that all means of influencing and educating the general public along these lines should be used *now*. This should be done in such a way as to form a climate of opinion favourable to an enlightened understanding of science and its potentialities for human good. In particular, appreciation of the methods of rational examination would help the public to assess the claims of politicians, advertisers and quacks at their proper value. We think that the B.B.C., because of its unique and central position and its all-pervasive influence, could bear a great responsibility in achieving these ends.

We are aware that scientific subjects have had a considerable share in the short-wave programmes for overseas transmission, but we want to press most strongly the view that science should not only be for export and propaganda purposes. It is our home population at the centre of this commonwealth of nations that urgently needs introduction to our point of view if it is to play its part in shaping the events to come. The home public should not be treated as children and given only what it is thought will amuse them. They should be led to appreciate features of more permanent value. We are aware of the valuable and carefully prepared science section of the broadcasts to schools, but science and scientific method are largely ignored by those who plan the programmes for adults. Yet the statistics of the B.B.C. itself show that a surprisingly large percentage of adults listens to the school programmes. This is evidence to rebut the suggestion that adults do not respond to programmes other than those classed as ' relaxation ' or ' entertainment.' Why is it that the entertainment value of science to adults, its power of quickening interest and giving new insight into the everyday world around them, has been so little realised ?

We appreciate the improvement that has taken place during the last year in the presentation of science by the B.B.C., but we submit that the time devoted to science in the home programmes still fails to reflect the reality of the place which science occupies in the life of our times or the need for its wider and more conscious application in the solution of many human problems. It lies within the power of the B.B.C. to play a part in the enlightenment of the twentieth century at least as important for human progress as that of the encyclopædists in the eighteenth century.

We have given some thought to the means by which the scientific attitude could be conveyed in radio programmes without dulling the appetite of the ordinary listener : we have many detailed and concrete suggestions to make ; but this is not the place for detailed recommendations. I will content myself with an outline of the general orientation which might be adopted.

We envisage two general trends which might be developed. First the adoption of a general scientific outlook or method of approach in all discussions, social, economic, educational and informative. Thus several speakers would be asked to contribute what they knew as facts about a given problem ; they would discuss, if necessary, what further information should be sought and how this might be acquired ; and, to conclude the colloquium, one of them might sum up the trend of evidence on the facts as known. Thus the scientific approach would be illustrated in discussing a topic of general interest, which should be related to the everyday life of the citizen and not necessarily a technical, scientific one. This would be in contrast to the present too common ' discussion ' which takes the form of speakers pro and con on a given subject with no conclusions drawn, and little consideration of facts, but only feelings.

Secondly there should be an increase in the specifically science programmes. This does not mean science in the limited technical sense but the following : the history of science, scientific discovery and development ; the lives of scientific workers ; the progress of science and how it has affected, is affecting and could affect ordinary life ; the part it is playing in the war and will need to play after the war ; the organisation of science itself, with special emphasis on its democracy and its internationalism. Programmes based on these lines should be tied as closely as possible to general matters of immediate interest to the people of Britain.

One way of inculcating the scientific approach would be to have a scientific worker as a regular commentator on passing events. This would show what events were significant as seen by a scientist ; often this would not be those events which filled the headlines of the press, but something of more social and economic significance in the long run. The scientific approach to the new, the unexpected and the controversial again could be made clear by the actual examples chosen, which should be of general topical interest.

It should also be recognised that this orientation of the programmes would not be satisfactory unless a reasonable proportion of these broadly scientific items appeared at the peak hours of listening. The best programmes during the hours when most people are at work are not likely to exert much formative influence on public opinion.

If science is to be properly presented to the public, the B.B.C. must be prepared to spend time and money on the selection and tuition of speakers. It is not sufficient to choose scientists just because they are eminent in their particular sphere. They may have a poor microphone manner and fail to secure an audience, for the same reason that the brilliant physician with a bad bedside manner fails to secure patients. It would be better to train a corps of less distinguished workers who know how to present their material. Just as theatrical producers have to spend much time training the actors, so the B.B.C. and the speakers must be prepared to devote time and money to tuition and research in this difficult matter of presentation.

There is one further point which, though not directly concerned with the presentation of science to the public, seems relevant to our discussion here. The B.B.C. is entirely a creation of science

and controls millions of public money. Yet, so far as I know, nothing is spent by the Corporation on fundamental research. We are all well aware of the *ad hoc* technical research which is undertaken to overcome problems of transmission, reception and the like, but we have in mind an institute devoted to whole-time fundamental research comparable with that undertaken by the Bell Telephone Company and similar bodies in the U.S.A. These corporations have been responsible for work that has profoundly influenced the development of fundamental knowledge of physics, and it is another reflection on our national attitude to science that a corporation of the size, influence and wealth of the B.B.C. has not realised its responsibilities in this direction.

Finally, I should like to put forward recommendations which I hope will be taken as a resolution by this Conference, for transmission to and consideration by the Council of the British Association. In order to secure the proposed re-orientation of the B.B.C. towards science in its programmes and to develop this field we would suggest the following organisational recommendations :

There should be a permanent committee of representatives of the scientific profession to advise on and to develop ideas for the B.B.C. programmes. This committee should have a status recognised by the B.B.C., and a Science Programme Officer should be nominated by the latter to work with the committee and to maintain liaison with the B.B.C. programme devisers and organisers.

The most skilled programme devisers and producers should be consulted at all stages as to the best methods of presentation, and adequate tuition of scientific speakers should be provided.

The Listener Research Department should be asked to prepare a report on the reception of scientific broadcasts and to make recommendations.

We should like to add the recommendation that this permanent committee should not be selected solely for scientific eminence and seniority, but it should include a fair proportion of younger men who are really keen to convey the scientific attitude to the public.

Miss M. A. Field

The Making of Biological Films

In speaking of the ' making ' of biological films, I am using the word ' make ' not in the technical sense of how the work of cinematography is actually done, but in the more general sense which involves discussion of the principles that lie behind the production of such films. I speak with experience not of camera work but of the general principles of production which result in the film as a finished whole.

In principle, a biological film is no different from any other kind of instructional film. In 1939, at the outbreak of the present war, some observers believed that Great Britain led the world in the production and use of the instructional film. It was not that we produced more of this type of film or showed more of them than the totalitarian countries, or France or the United States. It was in quality rather than in quantity that we held the lead, quality not merely of production but quality in the use made by teachers of those films that were available for their use. The reason for this quality lay, probably, in the enunciation of a definition for a teaching film to which the British film makers and British teachers adhered closely. This definition was slowly and painstakingly evolved by teachers in all types of schools, by a handful of university research students and professors, by a few education authorities, and by even fewer commercial film companies. The definition achieved is very simple : ' The instructional film is a piece of equipment in the hands of the teacher.' This has proved a first-class definition to work to, and should be adhered to until experience has given us something better.

The outbreak of war practically put an end to the production of instructional films. We have had an immense and, on the whole, excellent flow of completely different films, of propaganda films and of films designed to impart facts to vast numbers of persons in a short space of time. But there has been neither time nor place, in war conditions and under the dead hand of Government control, for the instructional film that is a tool for true education. The people who did the original experimental work in this field are temporarily scattered. When the war is over, it is to be hoped that they will have opportunities of renewing their highly individual yet closely collaborated work.

If a biological film is a piece of equipment in the hands of the teacher, lecturer or club leader, it is obvious that, for it to attain a maximum of utility, it should be correlated with all the other kinds of educational equipment employed. Any still pictures used by the teacher should be taken from the film or be analogous to the film scenes. Any strip-films or lantern slides should be made up from frames out of the film. Diagrams drawn on the blackboard should be similar in lay-out to any diagrams that may appear in the film, and, above all, the text-books used should take cognisance of the film or series of films. Before the war, still pictures from films were in great demand for illustrating text-books, and at least one popular biology text-book, *Looking at Life*, was specially written by two schoolmasters to be used in conjunction with a special series of films. In the whole world of teaching films, the best efforts to correlate the film with all other classroom equipment have been made by biology teachers. Of course, if a biology film is to be a useful tool in the hands of the teacher, he must be thoroughly familiar with it and able to use it whenever his class is ready for it. Thus the full value of biological films will never be achieved until every school, technical college, university department, and adult education centre has its own library of what may be called film ' classics ' together with the power of getting, at short notice, other films, that are recognised as useful, from a local film library. There is no real truth in the assertion that films are awkward to show in classrooms. Most intelligent teachers have already achieved a routine of projection which appears effortless and is effective. But, of course, the most enterprising teacher or lecturer is at a disadvantage in a building with no electric power.

Still, the greatest enthusiast for the biological film must in honesty own that it takes time to use

and is in many ways an expensive piece of equipment. What then are its qualities which make it worth while to expend time and trouble in order to show it? The outstanding quality of the film is movement. In biology not only can the film supply movements which it would be difficult for a class to see, but it shows movement that nothing but the camera can see—ultra-rapid cinematography gives us that analysis of movement we call slow motion, stop-motion cinematography gives us the speeded-up movement of plants and slow-moving creatures which enables the eye to appreciate that movement has actually taken place. One such movement, admirably shown by film, is the swaying of the maize plant which is caused by the strut roots trying to break through the earth's surface. In biology, too, the film can take the place of expensive and laborious educational journeys. It can bring the seashore and the under-sea to inland laboratories at any moment and bring a fresh supply of deep-water specimens to institutions which, in normal circumstances, they could never reach alive. Besides its inherent quality of movement, the biological film is a valuable piece of instructional equipment because of its illusion of reality and its close approach to actual experience. So a film, viewed by a group of people, can be an experience shared by that group. And, as all teachers know, this shared experience is the basis of true education, of the friction of mind on mind. A group can do field work together, at week-ends or on holidays, but with the help of a film students can visit tropical forests, the *maquis* of the Mediterranean, the Arctic and Antarctic regions. In summer they can experience a winter expedition, in spring they can observe the phenomena of autumn. The biological film can also give that unique experience, a common view by many people through the same microscope. Moreover, the teacher is certain of the behaviour of his specimens under that microscope and can be sure that all the group have had the same good view and the same opportunities of observation. This makes the individual use of the microscope more easy and, as one teacher said, one can check up on the over-confident student who asserts he has seen what he has not, and on the nervous student who is afraid to acknowledge he has seen what he has. Both have seen the same living specimen on the screen.

While one emphasises the valuable contribution of the film to biological education one must not forget to emphasise its limits. It is only a *piece* of educational equipment in the hands of the teacher. It cannot teach by itself, it cannot take the place of slow, painstaking personal observation and work. But for introductory or revision work, for showing movement of all kinds, and for studying the behaviour of specimens at all times of the year or over a period of years, it is invaluable—nor can biology be taught so well without its help.

Now, granted that biological films are of use in instruction—how should they be made? Rather more than twenty years have been devoted in this country to a method of producing biological films satisfactorily. And though we are still only at the beginning of our research, we have found a good working formula. First it must be decided for what group the film is being made. If the film is intended to be a piece of educational equipment, it can be framed for one type of student only. It is ridiculous to expect a film made for school certificate students to be used in universities, or for a university film to suit a more general W.E.A. class. Sometimes a teacher finds he can use a film for more than one age group, but that is only a lucky chance. The audience must be chosen and the film must then be related to the syllabus of study which that audience will undertake. While our schools and universities are ruled by the examination system they have no time to stray one inch from the curriculum. Central schools and adult education groups appear to be the only people who can stray into the pleasurable byways of biological knowledge.

Obviously the teacher is an essential person in the production of an instructional film. He uses it, he knows what he wants and what he will have time to show. Such a teacher should be appointed by a society of teachers and should not be too experimental or individualist. He speaks for the main body of teachers. But the practising teacher has not always access to the most recent biological discoveries. An expert biologist should, therefore, be appointed to see that the material in the film is correct. This expert should be appointed by an educational group that knows which expert is generally accepted as sound. Then comes the cinematographer who can film the specimens and who knows enough biology to keep those specimens alive but functioning normally under the most unnatural conditions. Finally comes the film director. This person is a sort of umpire between the three experts, seeing that each gets his way in what is essential, but that the film is not overweighted by the influence of any one of them. The director views the film as a whole and considers such things as continuity of picture, proper proportion and balance in the film, the right and valuable use of slow motion and stop-motion sections, the place for close-up views, the use of diagram, and many other things which make a film good or bad. If the film is to be used in silent form it must tell its own story; if it is to be used with a commentary there is an art in planning and fitting that commentary. Most biological films are used both in sound and silent form. If a film will be exported to foreign countries, the director must ensure that no writing appears on the screen. Indeed the direction of a biological film is rather like the publishing of a biological text-book. Its final form will enhance or almost destroy the value of its matter.

So the production of a good biological film is really a job of team work. The film so produced is usually used as a whole for introductory work or for recapitulation. But sometimes a teacher is glad of a short section from a film to illustrate one single point. The method of supplying these short sections has not yet been satisfactorily worked out. But I am of the opinion that it is in supplying such sections that amateur film-makers and film societies can do a most useful piece of work. The film 'classic' will for some time continue to be made by commercial companies who have the equipment and experience to make films that are generally acceptable. The amateur can well supplement these films by making pictures of detailed or exceptional pheno-

mena that will be of great interest to a limited public or useful for brief illustration. It must be remembered that the amateur is usually a specialist and his work is not always of general interest. There are signs of great goodwill between amateur and professional biological film-makers and I see no reason why, when conditions become more normal, the two groups should not work together in happy and useful collaboration.

One of the fields in which the amateur cannot compete with the professional on account of the complication of equipment, is that of the animated diagram. The diagram film, which, moving from still picture to still picture, is completely distinct from cartoon film which progresses from movement to movement, is invaluable for showing movements which can never actually be seen because they take place inside the living creature. The teacher can do a great deal on the blackboard but is limited, by having only two hands, to portraying only two simultaneous movements. The diagram can show any number of movements all taking place at the same time, can show them at any pace and can go backwards and repeat the action. Circulation, respiration and such functions can be shown in no other way. Frequently the director is called upon to cover blanks of ignorance on the part of biologists, for the moving diagram requires absolute and definite knowledge. For example, when a group of rabbit ova are fertilised in the Fallopian tube, does the first to be fertilised proceed furthest along the uterus while the others take their places behind it, or does the first to be fertilised take the first position in the uterus and let the others pass it? The diagram makers needed to know definitely. The director managed to avoid the issue. But in biology films the diagram does succeed in giving movement to those dynamic happenings which till now have had to be shown in static illustration.

Basing our deduction on rather meagre research, it appears that some elementary, senior and central schools use nature study films; some secondary schools, technical institutions and universities use biological films, but the choice lies entirely with the teacher. So long as there are teachers who say 'I can't think how people find time for films and work,' so long as examinations dominate school life, so long will the slow but invaluable method of film instruction by observation and discussion be at a disadvantage. It is regrettable that so little has been done for adult education with biological films. This is largely a question of projection facilities and expense. In other subjects the adult class is the one for which film teaching technique appears to offer the most and to be most valuably used. It is a pity that a general biological training by films has not been given to the public, for it would have done much to make a background for propaganda by the Ministry of Health and the Ministry of Food. It is to be hoped that this biological training will be given to our citizens in the future so that they may take an intelligent interest in public health. And the most effective way to give general biological education is undoubtedly by film.

I should like at this point to put in a word—a very brief word—for the 'popular' nature film which is sometimes shown in cinemas. To the biologist or even to the ordinary educated person, they may be anathema with their rather music-hall commentary and their anthropomorphic approach. But we are inclined to think that they have a valuable place in making the public in large towns aware of nature and its fascinating processes. We must remember the limited experience of many of our fellow citizens.

When nature films for cinemas stopped being made at the outset of war, the film trade asked for them to be revived. We have had many examples of these films doing valuable work in opening people's eyes to what is going on in the fields and hedges that they rushed past in cars on pre-war week-ends. No one would be more pleased than the producers to raise the general tone of the commentary when the general standard of education of cinema audiences has been raised. There are immense possibilities in promoting public knowledge of science by means of the cinema. These possibilities have still to be explored and developed.

Paul Rotha

Interpreting Science by Film

I AM a technician; and my craft is that of film-making. Because the film is a medium well suited to convey information to the community, I claim also to be an interpreter. My subject is, then, the interpretation of science by the film.

For a long time the understanding between society and science has been slender because it has been based on a mistaken idea of the scientist's work. It has been so easy to sell science to the people in terms of the celestial heavens and the magic switch. It has been so easy—and to certain interests no doubt desirable—to weave this shroud of mystery in which most of science has been veiled by popular novelists, film producers and other caterers to the public mind.

The material events of the war, however, are breaking down some of these barriers to a proper grasp of what is science. The technical training of thousands of men and women in the use of instruments and machines that are the result of scientific research and experiment must surely be doing much to shatter, once and for all, the old-fashioned conception. The hard fact that our weapons of attack and defence depend so largely upon the work of scientifically trained minds again makes science more alive to the citizen. There is growing up a very real demand for knowing what science is all about. Is that demand being met; and how can it best be met? I assume, of course, that the scientist himself wishes that it should be met.

Scientists themselves have recently produced two great media for the communication of ideas and facts—the radio and the film—in addition, of course, to the much older printing press. But so far these two new and powerful instruments have not been used regularly to interpret science itself to society in general. They have been worked full time and overtime to provide entertainment, to issue news, and to disgorge propaganda for many masters, political, commercial and religious. Science itself has had a poor New Deal from them.

'Science,' says Dr. C. H. Waddington, 'can only be effective as a set of ideas which permeate the public mind.' But as applied science enters more and more into current war-time activity—

in the factory and in the armed offensive on land, sea and in the air—people are seeing science mainly as a great destructor or a protector. Is there not an urgent need to tell people now, in simple, easily-understandable terms, that science can also be a great *constructor* ; that, indeed, without the scientist there can be no hope at all of a better world after the shooting war is over ?

I do not believe in working out a planned world, or a planned city, or a planned house for that matter, and forcing acceptance of it on the common man without first telling him all about it. He has got to desire it before he will accept it, let alone demand it. If the full resources of science are ever to be put at the disposal of the people as a whole, the people have first to know about the potentialities of science in its countless applied forms.

The popular phrases ' the century of the common man,' ' freedom from want and freedom from fear,' ' equal access to raw materials,' these must be shown as both practical and attainable as a result of a scientific approach to living. They must be, to use the old documentary film slogan, ' brought alive.' The film is a most suitable instrument to convey quickly and simply this information to the people. The cinema screen, whether in the public theatre or the village hall, is an admirable popular laboratory bench for trying out new ideas. With animated diagrams and maps, with real photographic images, with voices in all languages, with music and other emotional aids to presentation, we could show, for example, what the Tennessee Valley Authority really has done in the United States, and we could then show how a project on similar planned lines could be worked out for, say, the Danube. The peasants of the Balkans might be more interested than in a set of blue-prints. Anyone attending the Science and World Order Conference of the British Association in September 1941 could have heard discussed a hundred projects for films of international appeal and importance. Because science itself is international, films about science must be international in their conception.

Not only should films about science give facts, but they must present facts in such a way that may well invoke a call to action. If, for example, we show people by a film that nutritional science can, on the one hand, state what are the minimum requirements of food consumption for a healthy life to be led by the whole community and, on the other hand, state what kinds of foods should be grown to meet that need, then the audience is provoked to say : ' Who and what is standing in the way of this common-sense thing being done ? ' That is the mood of ultimate victory. If films about science are going to have real social purpose, they must give people facts and information not dryly but dramatically presented. Above all, they must create a desire among the people for science to be used for *all the people*, not for the privileged few alone.

These remarks apply, in the main, to films about science interpretation in general, films to show the ordinary person what kind of a world *can* be created *if* the full resources of science are used. But there are many other kinds of films about science, more specialised in their positive aims. Here are some of them.

Films are needed to educate our political leaders, industrialists, civil servants and others in whose hands so often lies the power to make use of science. Films are wanted to instruct employers just as much as to instruct employees. Films are required to meet the need of specialists in many fields, those who want to know how science affects their work in the public interest. For example, farmers need to know how scientific agricultural research affects their day-to-day activity. This is obviously a most important field—the film taking the results of research out to the people who can most benefit by them. Another kind of film can tell scientists specialising in one branch of work what workers in other branches of science are doing. There is need here for scientists to be able to relate their own work in perspective to that of others. The film can perhaps explain and demonstrate in a way that the scientific paper cannot do. Then, again, films can tell workers in all fields of science what their colleagues are doing in the same field. Here is need for accurate and careful recording, for the film camera and microphone to be used in their fundamental purpose as recording instruments.

This Conference is embracing the radio and the press as well as the film. I believe, therefore, it is important to make clear a distinction with regard to the film. Speakers will no doubt call for a wider and better use of space in the press, and of time over the air, for science interpretation. By so doing they seek admittance to pages that will be printed in any event, and to programmes that will go out from the B.B.C. as per schedule. The press and the radio, with rare exceptions, go on hour by hour, day by day. But in aspiring to get more films made to interpret science to the citizen we are starting from scratch, because the films will have to be made. Will the film industry find interest in financing films about science ? If not the film industry, then who ? The Government ? Certain films perhaps. The Ministry of Information's Films Division has earned for itself a good name by sponsoring quite a number of films in the science world in the last two years. Although much of its work must rightly deal with the immediate themes and subjects of war, the Films Division has also made possible for the first time in this country the production of films about such subjects as plastic surgery, blood transfusion, rehabilitation centres, tuberculosis, venereal disease, various aspects of nutrition and agriculture. It has, moreover, had made a film on the theme of world food production on a planned basis to meet world human needs. It made a film about the British Association meeting on Science and World Order and sent it out to allied and neutral countries. It is to be hoped that this promising start by the Ministry of Information for using the film to give information of social good to the public and to the specialist will not be cut short at the end of the shooting war, but will continue into the great social war to come.

Then who else is there to finance films about science ? Scientists or scientific bodies perhaps ? In some cases this may be possible, especially for highly technical films for domestic use. But films are costly and most scientists need money badly enough for their own research, let alone the making of films. Then there is industry. It is

welcome news here that a big firm like Imperial Chemical Industries has recently begun on a series of interesting films. The gas industry has for some years sponsored films on social reform in housing, nutrition and education; while the technical films of the Shell Film Unit are without parallel and have an international reputation. But private industry also has its limitations.

I do not know the answer, but the problem must be faced squarely if science is to make real, co-ordinated and wide use of the film medium. The need is there—the need for films, correlated with radio talks, journalism, books, exhibitions, museums, to explain and relate science in Britain to world science. The peoples in the United Nations and neutral countries must be given the chance to know how science has it in its power to bring about a more human and happier world based on scientific planning. We must remember, also, that immediately the Fascist enemy is beaten, there will be millions of people in enemy-occupied lands who are to-day starved of news and information. They, as much as anyone, will want to know what is the plan for world rehabilitation by the United Nations.

If, after the shooting war is over, there is going to be any real attempt to get the people of different countries to live on terms of peace and equality with one another, if there is going to be any real attempt to equate world production with total and unprivileged world consumption, if there is going to be any honest attempt to put into realistic terms such phrases as ' the century of the common man '—there will be the most urgent need for education and propaganda to show first that these things are possible. The film is one international medium which is most suited to be used for this purpose. Already plans should be in hand for international themes and subjects to serve this end. Progressive scientists and film-makers should be working on ideas which will range from simple technical films teaching this or that, to big international themes interpreting the world and its human needs in terms of raw materials, organisation and communications. The film must be called in to play its part in the pooling and sharing of scientific knowledge and experiment for the benefit of the people as a whole. It must be used as one of the great interpreters between science and society—the forerunner to society using science as its servant.

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At the conclusion of this session, thanks to the kind collaboration of the Films Division of the Ministry of Information, examples of scientific films were exhibited.

SCIENCE AS A HUMANITY

Sunday, March 21 : Morning Session

Address by
Prof. Sir John L. Myres, F.B.A.
Chairman

Let us begin by defining our terms. By science we may, I hope, agree that we mean the pursuit of truth by the study of the universe in which we are, and specifically the study of natural processes by observation and experiment. By humanity, and the humanities, we mean any system of thought or action which assigns a predominant interest to the affairs of men, as compared with the supernatural or the abstract. It is evident that there is some overlap between these two notions; and it is our business here to define and explain that common ground with a view to appropriate action in public life, and especially in the education of citizens, which is life-long.

Both terms imply, and presuppose, their opposites. Science, the search for truth, the advancement of knowledge, applies the test of accuracy and coherence to opinions and action not founded on observed fact and logical inference: its appeal is to reason and common sense: its conclusions are verifiable by observant and intelligent persons.

Humanism arose as the revolt of reason and common sense, in the ancient world, against tradition, authority, and privilege, acting in restraint of freedom to enquire and to testify in such matters of observation and inference: in the Revival of Learning, from the fourteenth century onwards, against mediæval traditions of scholastic theology and philosophy—supernatural or abstract—and especially against restrictions on intellectual freedom in the supposed interest of the Christian Church. Like the later humanism of Comte, it asserted the dignity and independence of humanity and of human reason. For guidance and for experience, it explored the works of the great masters of humanism in antiquity, while it applied to the study of nature their methods of observation, experiment and inference, and rapidly improved on them. The humanities have thus both a negative, defensive, protective function, and a positive, aggressive, and progressive: defensive against every derogation from the perfectibility of man as objective of human enquiry and effort; whether the alternative aim be the supposed glory of God or other supernatural ideal (and this was momentarily the greater danger to civilisation when humanism took shape in modern Europe), or the pursuit of wealth, dominance, or other form of technical control over men's lives and efforts. It was aggressive and progressive in its assertion of intellectual as well as civil freedom, and for fuller freedom of thought it cultivated freedom and facility of speech; again with constant inevitable recourse to the models supplied by the thinkers, writers, and orators of antiquity. A humanist who could not speak or write was like a scientist who could not conduct an experiment or read a foreign book.

From this historic humanism emerged not only modern political and moral philosophy, not merely the study of modern history, languages, and litera-

tures, but (no less) all modern exploration of the realm of nature, all that we mean by the advancement of science. Not only in historical origin, but in academic practice of British universities and the older British schools, what we call the natural sciences have never been beyond the pale of the humanities—and I am not speaking here of the faculty of medicine, but of the ancient faculty of arts, devoted to what we now call a 'good general education,' preparatory to any higher faculty or special study whatever. That is an historical documentary fact, which some critics either do not know or will not understand.

Inevitably, perhaps, but unhappily, the new romantic impulse to scientific enquiries, at the end of the eighteenth century, affected the other humanities, linguistic, literary, historical, and philosophical, no less profoundly than the natural sciences. Under the double impact of experimental methods on the one side and evolutionary theories on the other, the old 'arts faculty' fell to pieces. The best teachers in it had always been specialists and researchers and, mainly because they had freedom, allowed themselves time : the best students were now tempted—mainly for want of time—to forgo either the natural philosophy or the moral philosophy, in the wide meaning then still current for both groups of studies. The more humane letters (*Literæ Humaniores*) lost touch with the study of nature : that was mainly the fault of the philosophers. The new science courses lost touch with languages and literature : that was mainly their own fault ; for (again to save time as knowledge grew) they substituted 'science prelims.' for the old general intermediate course ; and sectional 'honours courses' for the old School of Natural Philosophy, which had included all the exact sciences then known.

In the great schools the change came more slowly ; but it was in the same direction. At Winchester, sixty years ago, mathematics and natural science occupied about a third of our formal school hours : how much of our private work was devoted to these subjects, or to field work in natural history, was entirely our own affair ; and meanwhile all but a few mathematical libertines followed the course in languages, literature, and history. In this deliberately humanist education, science was certainly one of the humanities ; and if education is to remain humanist (that is to say, is to assign a predominant interest to the affairs of men), science, the pursuit of truth about the universe in which we live, must have its recognised place in it. 'Let us insist,' as Dr. Born put it, at the discussion here in September 1941, 'on the dignity of science as an independent and free activity, solely devoted to the task of discovering the structure of the existing world.'

More serious impediments to the maintenance of science as a humanity have been the professional demands of the medical schools on the biological courses, and the vocational demands of industry on the chemical and physical. Long ago Gilbert Bourne told me that Oxford zoologists had no time to read the *Origin of Species*. And it has been poor compensation for shortened and overburdened courses at the universities, to cram the sixth form for 'science prelims.' before matriculation. These expedients may seem profitable training for a technological job ; but they are the antithesis of humanism. It may be too late to transfer the technical courses from the universities to industrial institutes ; the alternative is at least to reopen within the universities collateral avenues to a general humanist education on the lines proposed by this Association's Committee on Post-War Education, in its recent interim report.

Thus far, I hope we are in general agreed (1) that from the beginnings of a humanist outlook, in antiquity, and also at the Revival of Learning, the natural sciences had undisputed and indispensable place among the humanities ; (2) that they lost that place, no less inevitably, when the technological demands of modern industrialism claimed for them a status apart from, and alternative to, the 'more humane' studies, as it became the fashion to call them, in the hope of producing experts and specialists in some one line of lucrative research at the age of twenty-two or twenty-three.

That alternative technological aim and outlook, as we are beginning to discover, has its cultural defects, its positive deficiencies, as a preparation for life in modern society. In its unqualified claim, and in much current practice, it is indeed the antithesis of humanism ; for it precludes all but schoolboy study of those sciences which are concerned with man's place in society. No one can say that science has no place in society, when it is possible for a boy to become a chemist or an electrician at seventeen and go on doing little else but chemistry or electricity till he finds a job. But it is not class prejudice, not the 'old school tie,' but the need of the public services for men of humanist education, that prescribes humanist tests for aspirants to a humanist career, in the accepted sense of humanism.

I come now to the scientific outlook and method itself in its aspect as a humanity. It is sometimes contended that the motive of all scientific enquiry is to increase man's control over physical and biological surroundings, and that—whether explicitly and consciously or not—this is the primary (even the sole) incentive to such enquiry. Without disputing that this technical prospect, like any other prospect of power and control, is a potent impulse in many minds, a strong case may be stated for the existence of another motive, the desire for knowledge and understanding, quite independent of any such prospect of control, or even of use. This is most evident in astronomy and geology, where all evidence now open to observation illustrates events of distant date, and beyond man's control. It is attested by the devotion of children to the study of birds, insects, and plants, neither utilitarian nor even acquisitive. It is explicit in the confessed experience of many men of science. That some have not those experiences proves no more than does the testimony of others to their own insensitiveness to music and other forms of art, to the higher mathematics, and to emotional and religious experiences ; and of others again to their indifference, either to economic considerations, or to the 'scientific point of view' in affairs. Further, these natural gifts of emotional and aesthetic appreciation, of understanding, and of emulation may be awakened and enhanced ; with the relevant creative activity, and the scientific point of view—

above all, with what I venture to describe as the scientific *motive*, far beyond the scope of specific sciences or their applications. The Greek outlook, and those educational exercises which formulated, enhanced, and propagated it, are relevant (as Dr. Farrington will assure us) to our discussion to-day. For though the study of nature was hampered by almost unavoidable deficiencies, quantitative physical studies were regarded as indispensable preliminaries to mental, moral and political philosophy—not as applied sciences with economic objectives, but as a school for thought—in that fine Greek sense of the word *school* as a place where mental exercises go on undistracted by mundane and self-seeking considerations.

Speculative advances in antiquity were concurrent with observations and discoveries. Aristotle was a naturalist and a doctor. And conversely the recovery of Greek metaphysic was one of the first steps towards modern science, after the long mediæval meditation on things beyond time and space, and towards the new interest in facts and processes verifiable and measurable by everyone as illustrations of mathematical laws ; facts of motion in physics ; facts of weight and volume in chemistry ; of metabolism in physiology ; of more complicated changes in economics and psychology ; till it began to seem as if we could literally measure humanity.

But that was, and is, only one side of the matter. Whereas physical facts and events, in the widest sense, may be formulated by generalisation, and expressed quantitatively, when we study *man* and *men*—mind and society—we are dealing with reactions and interactions of individuals, incommensurable quantitatively, and different in quality and value. And these criteria of quality and value, the hypothesis of evolution traces back into biology, perhaps even further : ' doth not one star differ from another star in glory ? ' The old bifacial unity of knowledge, physical and metaphysical, reappears ; most clearly as to *man*, in modern psychology ; as to *men*, in geography and history ; fundamentally also as to *life* in biology. Historical and geographical science itself finds deeper and wider scope in geology and astronomy, where the facts and processes we study are inexplicable in their sequence and distribution, except as consequences of some individual breach of uniformity.

While, therefore, it is not fair to the citizen-to-be to stint him in the opportunity of experience of the quantitative ' order of nature,' it would be no less unjust to ignore the ' world of values,' remembering Huxley's antithesis between the cosmic struggle and man's struggle to give effect to his moral ideals. Humanity is inevitably in life-and-death struggle with physical nature ; and the wider men's conquests, the more exposed are they to counter-attack on many fronts. The greater the freedom of scope for individual character and achievement, and the temptation to rely on physical means to achieve ever greater power, the more urgent is it to habituate free and able men to respect and to value each other's personality, by which I mean their individual incommensurable uniqueness. That mutual reverence—for which the Greeks first found a specific name—is the sole basis of freedom.

It is therefore especially for those most intimately acquainted with the advancement of science to ensure that scientific studies, whatever their physical standpoint and present applicability in an order of nature, yet somehow contribute—as I am convinced that they can—to the advancement of humanity in a ' realm of ends.'

For as one of the greatest of ancient teachers, Zoroaster, said, in the world there is good and there is evil. They are in constant, but not eternal conflict ; for good must win. Yet good can only win if all good things, employed by all good men, work together in the cause of good, to leave the world better than they found it. That, I suppose, is what a humanist means by the Advancement of Science ; what a physicist means by Science as a Humanity.

Prof. B. Farrington

Science and Society in Ancient Greece

I HAVE been asked to speak about science in the ancient world. In the time at my disposal I have thought it best to speak about a limited portion of that great subject. I shall speak about the rise and fall of Greek science. But I hope to do so in such a way as to throw light on the fundamental relations between science and society in ancient times.

My subject is Greek science, not Greek philosophy. They are not the same thing, though they are often confused. Greek philosophy is the better known. It has been continuously studied in Western European countries since the thirteenth century. Greek science has only comparatively recently become a subject of systematic study. It is still studied by comparatively few persons. The extant texts are still far from being adequately edited ; and the scholarly apparatus which so well serves the study of Greek literature and philosophy will require much improvement before it becomes a satisfactory instrument for the study of Greek science.

The revival of interest in Greek science is due more to the growing prestige of modern science than to any other cause. As modern science has developed it has created the need for a better understanding of its past as well as of its function in the general life of society. The existence, within the British Association, of a Division for the Social and International Relations of Science is one proof among others that scientists have become socially conscious. There is also abundant proof, in the books that pour from the press, that scientists have become historically conscious. This is a very important development of our age. It puts science among the humanities. It is, indeed, difficult to imagine any intellectual activity more deserving of a place among the humanities than a scientific movement which has developed a social and historical sense.

For this new humanistic science the early period of Greek thought has a unique importance, inasmuch as it was then for the first time in history that the scientific outlook found conscious expression. Greek science is commonly allowed a history of some nine hundred years, from about 600 B.C. to about 300 A.D. But not all these nine hundred years are equally important. The truly formative period is the first two hundred years,

from 600 to 400 B.C., the period of the Ionian Dawn. From the philosophic point of view this is generally called the pre-Socratic period of Greek thought, the name carrying with it the implication that it was but a prelude to the serious philosophical development which began with the Socratic schools. But from the scientific point of view the Socratic schools initiate a decline. The name pre-Socratic is therefore falling into disfavour with historians of science, who prefer to give to this early period some more complimentary title, such as the Heroic Age of Greek Science.

The only other period of Greek science which can be compared with this is that which begins with the biological researches of Aristotle in the Lyceum at Athens, about 330 B.C., and includes the work of the Alexandrian scientists down to Hipparchus, about 130 B.C. This second period, which also covers about two hundred years, might be called the Age of the Text-book. From it date great monuments of orderly science like Aristotle's *Parts of Animals*, Euclid's *Elements*, Aristarchus on *The Sizes and Distances of the Sun and Moon*, and Archimedes on *Plane Equilibriums*. But this great period, though it marks an enormous advance in various departments of knowledge, already reveals that the promise of the Ionian Dawn is not to be fulfilled. Strong in the mathematical and deductive side, it is weak in observation and limited in range. Physics and chemistry have failed to develop. Practical applications of science are few.

It is to the earlier period, then, as the more important, that we shall particularly address ourselves this morning. Then for the first time in history was clearly conceived and expressed the ideal of a scientific attitude to external nature, to man, and to society. We shall enquire into the origin of this unique movement, its nature, and its end. Why should it have arisen when and where it did? Why did it not persist? What did it achieve?

In attempting to answer these questions we encounter at the outset a formidable obstacle. Though the object of the early Greek thinkers was to establish a scientific outlook on the whole of nature and of life, modern historians have conspired to describe their achievements as a miracle. This is a tribute to the brilliance of their ideas but a sad comment on the success of their endeavour. The Ionians sought to banish miracle from nature; now their own achievement has become the great secular miracle. It may be said that the word miracle in this connection is a mere metaphor. Perhaps it was so intended, but the word has now become a refuge for those who fail to offer any real explanation of the origin of scientific thought. We must eliminate this miracle. Nor does it seem impossible to show that the first and greatest period of Greek science is completely explicable within the limits of normal human experience. This ambition, now openly professed by some historians of religion in their own sphere, is surely not out of place in a historian of science.

In order to rescue Greek science from the realm of the supernatural and restore it to the realm of nature, the first thing needed is an accurate definition of its essential quality. It is generally defined as the first attempt to give a rational explanation of the universe. This is an unsatisfactory definition. The word rational is out of place. It was, in fact, precisely in the name of reason that Parmenides and Plato attacked and rejected the Ionian mode of explaining nature. The originality of the Ionian method of explaining nature was not that it was rational. It was that it sought to interpret all nature in terms of the familiar processes by which man himself exercises control over limited portions of nature's domain. The early Ionians did not fully *understand* those processes, but they could *control* them. They banished the supernatural, not by logic (it was by logic that Plato restored it), but by the assertion that the things above and the things below, the things going on in heaven and the things going on under the earth, were the same sort of things as were going on in the kitchen, in the workshop, on board ship, on the field of battle, on the farm. What the sun does when it ripens grain, or what the stomach does when it digests it, is the same sort of thing as a man does when he cooks it. What the sun does when it sucks up vapour is the same sort of thing as a man does when he boils water. If I can harden clay by firing it, this will help me to understand the formation of the earth. If I can measure a field, I can learn to measure the heavens. If I have reason to suppose that sun and moon are lumps of earth and am puzzled to understand why they do not drop from the sky, I do not remain puzzled until I have worked out a logical theory of centrifugal force. I am satisfied to swing a bucket full of water over my head and note that it can be done without the water descending on me. Such was the temper and such the achievement of Ionian science. In the revolving fiery wheels of Anaximander's mechanical universe, in the Upward and Downward path of the elements in the system of Heraclitus, in the atomic theory of Democritus, we have efforts to interpret nature in terms of the practical activities of man.

There is evidence enough to prove this point. This way of explaining nature belongs to a period when techniques are held in high honour in society, and form an integral element in the culture of the dominant class. Such, we are entitled to suppose, was the state of affairs in Miletus at the end of the seventh and the beginning of the sixth century, when the new mode of interpreting nature originated there. We have no reason to believe that such a state of affairs had ever existed before in the history of the world. The Ionian Greeks were heirs of the technical achievement of Babylon and Egypt. They were an expanding commercial community exporting the products of their techniques. They assimilated and improved upon the technical lore of the ancient East, but they did not take over from the civilisation of the old empires their mythological explanation of natural phenomena. They looked upon that as part of the technique of government in despotic societies for which, in their free city-state, they had no need. The evidence of language confirms the record of history that techniques were at this time held in high honour. The word *sophia*, which means wisdom, meant also, in the sixth century, technical skill.

Furthermore, direct proof of the decisive influence of techniques on the thought of the early

Ionians is supplied by the fragments which survive of their writings. The recorded opinions of Thales, Anaximander, Anaximenes, Heraclitus, Empedocles, Anaxagoras, and Democritus are interlarded with references to techniques and show obvious debts to technical processes. Among the technical instruments or processes which influenced them, and most of which are mentioned by them, are the potter's wheel, the bellows, the soldering-iron, the fulling-mill, the sling, the sieve, the bow, the lyre, fermentation of drinks, baking, the water-clock, the phonetic alphabet.

The distinctive thing, then, about the Ionians was that they sought to interpret nature in terms of these creations of man's ingenuity. They thought that man had acquired his techniques by imitating nature, and that successful control of a technique was therefore a guarantee of correct knowledge of nature. The distinction between technical and natural knowledge did not exist. The universe was an elaborate machine into the workings of which man's practical activities gave him insight. The attempt to give a rational account of nature came later. Two hundred years after Thales, in the next generation after Democritus, Plato, in the *Timæus*, attempted a rational account of creation in terms of mathematics. In the course of doing so he criticises the older Ionian mode of interpreting nature, derived not from mathematical reasoning but from physical processes. These processes he enumerates. They are solidification, liquefaction, inflammation, coalescence, distillation, condensation, and what we might call felting, a term derived from the cloth industry (*Timæus*, 49). It was this attempt to interpret nature, not in terms of abstract reason, but in terms of physical processes controlled in the potter's yard, the smithy, the cloth factory and other centres of production or practical activity, that was the specific originality of Ionian science.

In his last work, left unrevised when he died in his eighty-first year, Plato makes his most determined attack on the Ionian school. In stating their point of view as a preliminary to rejecting it, he gives us, in one pregnant sentence, an insight into their view of the relation between technical and natural knowledge. 'They claim,' he says, 'that the most valuable of the arts are those which blend their own power with that of nature, like medicine, agriculture and gymnastic.' Here is revealed the very heart of the older Ionian view of things. The power of nature is the same as the power of techniques. Man understands nature because he imitates and co-operates with nature, because he has mastered arts which blend their own power with the power of nature. Plato, the champion of reason, had a startlingly different conception of the nature of knowledge. He said true knowledge was a recollection of what the soul knew before it came into contact with this world. This description eliminates from knowledge the practical activity which, in the Ionian view, was its necessary basis.

The thinkers of this early Greek period, the Heroic Age, reached certain conclusions of absolutely fundamental importance for the future development of science. These conclusions may be reduced, to suit the scale of this paper, to two. First there is the view, clearly expressed in the writings of the Hippocratic doctors, that true science is a body of positive knowledge slowly acquired generation after generation by observation and experience, and tested in practice. The rôle of reason is to order and interpret the data of experience. This view of science involves the corollary that the growth of positive knowledge will limit the sphere of the divine, because 'men call divine everything which they do not understand.'

The second point is the experimental demonstration that the fundamental processes of nature take place by interaction between bodies too subtle for our senses to perceive directly. This view was first brought prominently into notice by Empedocles. Trying to establish a relation between the circulation of the blood and the external atmosphere, he devised experiments to prove the corporeality of the invisible air. His younger contemporary Anaxagoras had a neat lecture-room demonstration of the limits of accuracy of our unaided senses. He would pour drop by drop a black liquid into a white. Obviously the change of colour must have accompanied the fall of each drop. But several drops had to fall before the eye could perceive the change. This same doctrine, supported by a vast array of observed instances, was the necessary foundation of the ancient atomic system. In his exposition of that system Lucretius again and again insists on the fundamental principle that 'Nature works by unseen bodies.' This inference, drawn from direct observation of the phenomenal world, of the existence of an unseen world too subtle to be perceived by our senses, marks the limit beyond which science could not advance until the fresh growth of techniques in modern times had presented it with instruments of observation to refine and multiply the powers of our senses.

It was in the name of reason that the revolt against this earliest scientific movement in history was begun. But it would be naïve to see in the decline of Greek science, which began to set in after the Heroic Age, the victory of one abstract principle over another, of reason over observation. Ionian science arose in a definite social context. It began to decline when that context no longer existed. The necessary condition for its appearance had been the existence of a society in which the leaders of culture had a direct interest in the progress of techniques. It began to decline when the growth of the institution of slavery produced a form of society in which the leaders of culture did not possess, and were anxious above all to disavow, any interest or connection with techniques, except the gentleman's technique of reason, or talking, for both of which the Greeks used the same word. It was in a slave society that the idea arose that conversation is a form of research. We have an imperishable monument of this sort of scientific activity in the Socratic dialogues of Plato.

Pliny, in his *Natural History*, completes a survey of what he calls, in good Ionian terminology, 'the works of human ingenuity by which art imitates nature,' and adds this comment: 'With great wonder I observe that fire is almost everywhere the active agent.' But it was not only in transforming matter that fire was active. It also transformed man, physically and socially. Seden-

tary employment by the fire produced a special type of man. The Greeks had a name for him. They called him *banausic*, and they disliked and despised banausic man so much that they did all they could to emancipate the citizen from contact with the banausic arts. This prejudice, if prejudice we may call it, and not a realist appreciation of a grim social fact, extended also to agriculture and other productive pursuits. But in separating the citizen from fire, and from other technical processes, the Greeks separated the citizen from his best science masters. Mathematics and logic flourished, all science involving physical operations was threatened and sooner or later succumbed.

In a passage in his *Laws* Plato clearly reveals to us the dialectic of the situation. 'We have now made excellent arrangements to free our citizens from the necessity of manual work; the business of the arts and crafts has been passed on to others; agriculture has been handed over to slaves on condition of their granting us sufficient return to live like gentlemen. How now shall we organise our lives?' One part of the new organisation of the lives of the leisure-class citizens was a new outlook on the world, an outlook not based on techniques, not banausic, like that of the old Ionians who had created what we now call the scientific outlook. Our clearest and fullest expression of this new outlook is found in the *Metaphysics* of Plato's pupil, Aristotle. In this book is expounded a philosophy which finds the highest exercise of man's spirit in an activity described as 'thinking about thought.' Only so much of the Ionian view of things is reported as contributed to the formation of Aristotle's own conclusions. That is to say certain abstract formulations of opinion on the nature of things are quoted from their writings, which they are said to have arrived at purely as a result of curiosity. We are, somewhat to our surprise, assured that these opinions 'had nothing to do with production,' which reveals the embarrassment Aristotle felt at finding these old writings so full of allusions to techniques. The *Metaphysics* of Aristotle later proved an obstacle to the revival of science, when science had again in modern times acquired a practical end. This is in no way surprising when we remember that its original function was to dissociate science from practical ends. It is for this reason that Francis Bacon, who wished to reconstitute a science capable of yielding results useful to man, expressed the opinion that the works of Plato and Aristotle had survived the barbarian deluge, which overwhelmed ancient civilisation, because, being of lighter substance, they had floated on the waters in which weightier matter had sunk. Bacon's judgment is not the whole truth, but it contains an important element of truth.

We conclude, then, that Ionian Science is not miraculous in origin, but a mode of interpreting nature which was conditioned by historical circumstances; that its specific originality consists in interpreting nature in terms of the techniques by which men then manipulated nature; that it changed its character, tending to become exclusively logical and mathematical (what Bacon called 'disputatious'), when the growth of the institution of slavery separated the citizen from most forms of practical operational control of nature.

Bibliography: I acknowledge a special debt to R. Mondolfo's *Sugestiones de la Tecnica en las Concepciones de los Naturalistas Presocraticos* (*Archeion*, Nueva Serie T. ii. Vol. XXIII, 1941, N. i).

F. R. G. Duckworth

I SHOULD like to consider this problem from the point of view of schools. At the school stage, science, including mathematics, is in a certain sense the most philosophical of all the studies attempted. There might be something to be said for reviving its old name of natural philosophy. It begins—or should begin—with reflecting upon many sides of the boys' immediate environment; it proceeds, by way of observation and experiment, to the establishment of a chain of cause and effect, and the formulation of general principles. Furthermore, it has a most powerful fascination for a very great majority of boys (but not for all boys) and—perhaps in a rather different mode—for most girls. I do not think myself that it ought to be altogether dropped at any point in the school course. At the same time it has its dangers. Its claims can be—and sometimes are—too strongly pressed. From what I have heard and read there are those who would maintain that it is the one thing which matters—that there is no benefit conferred by the other subjects of study which is not also in the gift of science.

Now it seems to me clear that there is no department of human activity which has not been aided or enriched by science, and there is no field of study which cannot be approached in a scientific spirit. But to say that the scientific approach is the only approach or the scientific mode of thought is the only mode seems to me to be demonstrably untrue. I would illustrate the true state of affairs in this respect by a conversation I once had with a colleague of mine who is not only a scientist but a militant scientist, one who without hesitation affirms that science is of all subjects of the curriculum the most important. We were discussing a few years ago Sir Walford Davies' broadcasts on music—those broadcasts in which he analysed certain musical effects. My colleague, who is not only a scientist but also a musician, criticised these broadcasts with the utmost vehemence. In his opinion they were exactly calculated not to foster but to destroy musical appreciation. The beauty of great music, he said, cannot be analysed or measured. He supported his case by a parallel. The anatomist, he said, can show you exactly how a frog's legs work—whence it derives the power which enables it to leap; but, said my friend, what his anatomical dissection will not do is to bring home to you—to make you appreciate—the astonishing grace and beauty of that movement. When I asked him whether he would condemn biology for that reason, he said No: there was no reason that he could see why the biologist should not carry on with his job, and the artist with his quite different job. The problem my friend raised is familiar to those who have attempted to teach literature. There have been those who have attempted a scientific way of teaching school children to appreciate poetry or drama. Appreciation does not come in this way.

But if my colleague and I had continued our conversation we should soon have reached the point at which three considerations of importance would have emerged. We should first, I think, have noted that the epithet beautiful is applicable to much of the scientist's achievement. The demonstrations of the great mathematical physicists, for example, have been described as ' beautiful and of an almost divine simplicity.' And then perhaps, going on from that, we should have reflected that in the mind's working of the great scientists there is something intuitive at work—imagination, if you like to call it so : I am thinking of that moment in which a mind long baffled by an array of intricate problems sees in a sudden and quite unaccountable flash of illumination the solution of all its difficulties.

I suggest, therefore, that while science and the humanities are distinguishable, yet it is doing no service at all to education to set them in opposition to each other. Men speaking with far greater authority than I possess have said this. For instance, Whitehead notes that Shelley loved science and was never tired of expressing in poetry the thoughts which it suggests. Shelley had organised his experience—which is only another way of saying that the most ethereal of the Romantic poets was incapable of conceiving that there was any antagonism between science and poetry.

R. V. Southwell, F.R.S.

GIVEN a theme as wide as ours is this morning, and allowed for his essay only 2,000 words, it seemed to me that a speaker has no choice but to fix on some special aspect, hoping that a partial contribution may blend in a general design. I, therefore, addressed myself to this question : When we considered yesterday the exposition of science by radio and cinema, when we come this afternoon to consider our relations with the press, what kind of *recipient* do we contemplate, what should be the nature of the ' average man ' to whom our expositions will be addressed ?

It is a question which concerns me as an educationalist, since wanting an answer we shall plan curricula in vain. I say this neither because I disbelieve in planning, nor as introduction to yet another pronouncement on post-war education —which, since henceforth I may be expected to implement my pronouncements, I certainly do not intend. (Wiser, I think, the artist in *Don Quixote*, who being asked what he was painting replied ' That is as may turn out.') I put the question simply because it seems to me to be essential ; just as, set to design some form of transmitter, I should ask for details of the receiving mechanism.

What sort of man is to be the ' receiver ' of our contemplated transmissions ? (We are concerned now, I take it, not with the 3,000–4,000 on whom this Association can count, in peace time, at its annual meetings, but with a whole nation.) Will his interests be predominantly scientific and materialistic, as now (I suppose) they are in Russia ; or will he be ' humanistic ' and obtuse to the outlook and spirit of science, like so many of our headmasters, civil servants, ministers, and rulers generally ; or something more balanced and adult ? On the answer to this question, I suggest, must depend the content of our scientific ' talks ' and journalism ; whether these shall be cosy chats about the ' Wonders of Science '—new jargon for the dinner-table—or talk to which grown folk can listen, of men describing their work and aims. Within limits, we can have which we choose.

I hope that I shall not be judged to be here under false pretences when I say that in my belief science, regarded educationally, is not enough. I hold it a reproach to humanists that now the pendulum should have to swing so far that men talk as though it were. Paying lip-service to balance and breadth in education, in the past they have so limited its content that still men go out from our universities who hold it a stigma on any branch of knowledge, that it can be turned to practical use. (Indeed, they have infected even men of science ; so that some would now claim precedence for physics studied as an end in itself, and impose a due subordination on physics pursued for application, taking no account of intellectual effort—surely the true criterion ? Perhaps the needs of war are stamping out these last embers of eighteenth-century snobbishness !)

To me it seems negation of all experience to suggest that one-sided development, in whatever direction, should be an aim of education. I deplore contentious rivalry between science and the humanities, as though the question were or should be ' Which side shall win ? ' I have said that in my view (to use a nursery plea) the humanists ' started it ' ; but now that science is on its way to a place in the sun, is there no risk of our failing similarly to turn out balanced citizens ? It seems to me that the risk is great—and all the greater because in these war years our energies have been rightly concentrated on practical ends—unless we are prepared to face the question squarely—What is the cultural value of science ?

I have said that I do not find this in its story of material achievement : I find it rather in its development of *a special kind of thinking*, and my purpose to-day is to urge that not factual knowledge, but some acquaintance with scientific thought, is what is wanted in the education of ' normal citizens.' No matter how far we develop our apparatus for scientific exposition, I see no chance of our message falling on receptive ears so long as we are known merely as men who do particular kinds of things, not as men who reason in particular ways. It is our mode of thinking that we should emphasise, not results ; and unless education is balanced, so that other modes of thinking are recognised and in some degree acquired, we shall fail because *our* thinking will not be recognised as of special kind.

Much is written to-day which seems to postulate that scientific is the only ' right ' thinking—a panacea for all our discontents. To me, on the contrary, all experience seems to show that scientific thinking, *outside the laboratory*, is not enough : if it were, then all good scientists would be as competent in affairs and negotiation—which is manifestly not the fact. ' Life is the art of drawing sufficient conclusions from insufficient premises.' It calls for many-sided development : scientific thinking—which abhors insufficient premises—is needed, but is not enough.

Various kinds of thinking can be recognised as facets of a fully developed personality : I hold

that all of them we must try, by education, not to instil—for that is impossible—but to develop. There is, for example, the thinking that is needed for appreciation of the arts. This, of all kinds of thinking, seems to me farthest from the scientific thinking that is our concern this morning, and regarding it I will say only that in my belief, and from some observation as a father, it is of the essence of aesthetic enjoyment that it be coupled with a sense of personal discovery ; that it is a mistake to teach children positively that this and that they *ought* to like as being good. I suspect that we can do no more for their happiness than to put them in the way of such discovery ; and that this is more likely to result from our encouraging them to *create*, however crudely, than from lectures on ' aesthetic appreciation,' however good. Of this I am convinced, that it is no field for scientific thinking ; and every artist who has listened in bewilderment to a scientific ' analysis ' of his methods will, I think, support me here. He does not analyse when creating : he feels.

Another distinct kind of ' thinking ' (it is not the word I want, but I can find no better) seems to me to be trained by the study of languages. It is the effort that a mind must make to put itself in sympathy with others ; and the slang phrase ' He speaks the same language ' makes the point that I have in mind. I fancy that it is the kind of thinking in which we English are most deficient ; but what matters this morning is that it is quite unlike scientific thinking—yet a kind much needed in these days.

But no less needed—and perhaps even less definable—is the thinking which reveals itself as wisdom in the affairs of life itself : unformulated, sensitive both to present circumstance and past experience,—*νοῦς*. I am not sure that it can be taught, save by example ; but the humanists claim that it is nurtured by their studies, and I think that I have noted in them a suppleness (if the word will serve) to which men of science should aspire. Here then is a case for ' the humanities ' in a balanced education, and in my belief they are an essential part, though I am by no means content with the way in which they are studied under our examination system. I can perceive, I think, the dangers of teaching so completely based on authority : too often, as it seems to me, dislike of the premature conclusion leads to a shunning of decisions in a world where decisions are imperative. But what still is wanting science, I believe, can give : realisation that hard problems demand hard thinking, and that the effort must be made.

It is here, in a truly balanced education, that I see the rôle of science ; as a kind of thinking which, more than any other, faces the inexorable in our universe, and out of what was once a terror extracts a good : knowledge of that universe, which is certain good, and the power that is also good if used aright. But as I maintain (and it is the burden of my talk this morning), they only can appraise the treasure who know something of the quest.

We are concerned with ' average citizens,' and I am not so impractical as to believe that all can know the ardours of discovery, and that every schoolboy should be taught to ' do research ' ; though I would say, that to gain some understanding of scientific method it is not necessary that he attack a problem hitherto unsolved : only let it be new to *him*, and he may know the happiness of the pioneer. What I do believe is that to give him factual knowledge only is to leave him still in ignorance of what science really is ; that unless he acquires some understanding of its method, of the scientific approach, he will get nothing beyond a fleeting titillation from learning of its results.

But for those who have left school and can no longer study systematically, is there any alternative, really, to the instillation of results ? I think that there is, if teachers will have recourse to the history of science, and to the lives of the great pioneers. Let the learner be shown the problem as it looked *before* it was solved ; let him follow the groping steps of those who made the first approaches, and learn the way in which light dawned at last. Thereby he will come to see that scientific discoveries are not, as he had thought, based on a kind of magic, but on man's determination to win by labour, however fallible, through to victory over an adversary—Nature—who ' gives away no secrets, but always plays fair.' Brilliant as is modern exposition of the ' Wonders of Science,' I believe that this, the biographical approach, has wider human appeal and will bear more fruit. Factual description of the Rutherford atom may be given with a wealth of imagery and apt analogy, yet (I suspect) is too often received lethargically, without intellectual response ; but who would not be thrilled by the story of Rutherford on that triumphal evening : ' It was as though you fired a 12-inch shell at a sheet of cardboard, and it came back at you ' ? No one, I think, for whom scientific presentation has any value at all.

I end on a different note. Let us be careful, in our planning for education and for citizenship, not to waste the greatest of our assets—that heaven-sent gift of humour which makes our ' common people,' as I believe, the finest ' common people ' in the world. It is a salt in the English character whose savour is indefinable, yet can be recognised by anyone who will join the crowds that on Sundays listen with ribald tolerance to our zealots in Hyde Park. It has neutralised to our benefit, time and again, mistakes in official policy ; and we need not doubt that it will do so now, if our present planning be amiss. But we should look to it for more than mere insurance against mistakes ; we should recognise it for the good it is. We who plan for education are deeply in earnest : let us remember that those for whom we plan, these English whose future we seek to mould, mock at our labours for their good ; and may be right.

Prof. W. E. le Gros Clark, F.R.S.
The Place of the Biological Sciences in the Humanities

A DISCUSSION of the place of the biological sciences among the humanities inevitably raises the question of what is meant by the term ' humanity,' and here a difficulty arises, for it is capable of varied interpretations. According to Fowler's *Modern English Usage*, the first humanists were those who in the Dark Ages put themselves in opposition to the divines by turning their attention

from theological studies to the purely human achievements of the pre-Christian philosophers and writers. At that time, therefore, the term 'humanism' came to be associated with the new progressive and liberal aspects of education. To-day, by a curious inversion of meaning, the humanities are commonly taken to refer to the study of the activities of man in past ages in contradistinction to the study of all those problems which face mankind at the present time. Yet, if the term 'humanities' is employed in a rational sense, it seems even more appropriate in reference to those subjects which are most intimately concerned with the individual man of to-day, and with the study of his contemporary social environment. 'Knowledge is humanistic in quality,' says Dewey, 'not because it is *about* human products in the past, but because of what it *does* in liberating human intelligence and sympathy. Any subject matter which accomplishes this result is humane, and any subject matter which does not accomplish it is not even educational.'[1] The development of an adequate philosophy of life must involve an appreciation of life as it is now experienced and as it is likely to be experienced in the immediate future. Therefore, since the changing world of to-day demands above all else an appreciation of the possibilities of the control of nature in the interests of mankind, an insight into scientific methods may be taken to be an essential element in the educational development of a philosophy of life that is to have practical value. This is not to say that a study of the intellectual achievements of men in the past is of minor importance, for the information to be derived from a survey of historical progress is very great. But it is sometimes hardly realised that the outlook in ancient times was extraordinarily limited by a profound lack of factual knowledge, and also that the social environment and the factors which complicated the contemporary problems then were entirely different from those which exist to-day. From this point of view, any attempt to solve modern social problems by seeking to apply directly the solutions which seemed in the past to be effective is fraught with great danger. History can never recur in cycles sufficiently identical to permit the uncritical application of old methods to modern problems, for the simple reason that the steady progress of knowledge continuously introduces new factors which require to be taken into account. But the progress of knowledge in modern times has been essentially the progress of scientific knowledge and scientific method, and their impact on philosophical thought. Hence it may be argued that no man to-day can properly consider himself cultured unless he can base his own philosophy of life on the foundation of a knowledge of science and scientific method.

Since man himself is, after all, a member of the animal world, those sciences which are concerned with the study of life and the conditions of living have an obvious claim to be regarded as a 'humanity.' But in the past, biological education in schools and universities has often met with disappointing results because it has been confined to the study of subjects whose relation to mankind is not immediately apparent, or at least not specifically emphasised. No doubt this is a result of the fact that when science was first introduced into educational curricula it was treated along the traditional lines which had already become fixed for other subjects. That is to say, it was simply used as an additional medium for mind-training, as a sort of mental discipline which was regarded as necessary for the growing child. Hence the learning of science came to involve the accumulation of isolated facts and the memorisation of isolated and often out-of-date theories, and it seemed to be little more than an excessively dull means of inculcating knowledge simply for the sake of the knowledge itself. But the main interest, and indeed the value, of biological knowledge in general education lies in its application to the current problems of mankind, and in a real appreciation of the fact that only by the application of scientific method can these problems be solved. In the past the pursuit of knowledge by scientists often seemed to bear little or no relation to the practical problems of existence, even to the scientists themselves—it had the appearance of being the pursuit of pure knowledge without reference to practical considerations. Yet it has often been pointed out that such a conception of 'pure science' is misleading, and that even the 'pure' scientist is ultimately motivated unconsciously by the changing needs of his social environment. If this is recognised as being so, it becomes clear that a considerable short cut can be made in scientific education by making the pupil consciously aware of the relation of scientific knowledge and method to the practical solution of the problems which face mankind. More than that, it provides an interest and incentive to which the adolescent mind is peculiarly susceptible. This question of incentive is important for education as a whole. It is not an uncommon experience to find that those who come up to universities seem still to be astonishingly uneducated in spite of some years spent at a public school. They often have little or no capacity for reflective thought, for the clear formulation of a problem, or for precision of statement; they are sometimes hardly capable of writing good English. Such poor results are apt to be ascribed to a too early specialisation which takes up time better employed in the basic subjects of English grammar and literature and the classics. But there is no reason to suppose that with the curricula available at public schools any pupil is not given adequate facilities to master his own language and to cultivate the means of expressing himself clearly. I suggest that the main fault in the present-day school curricula lies in the absence of a real incentive to learning, and in the development of a certain cynicism and apathy of mind because the subjects as taught at school seem to bear too remote a relation to the various problems which loom so large in the world in which the pupil is growing up. I suggest, further, that the incentive can be provided by the development of science as a humanity. Scientific knowledge and scientific method, properly taught by inspired teachers, will develop a spirit of adventure and hence a real enthusiasm for learning. For, compared with subjects comprising the humanities as they are understood to-day, science develops the frame of mind which looks forward to the future, with all its unbounded

[1] *Democracy and Education*, 1916.

possibilities based on scientific research, rather than back to the so-called golden ages of the past when, for all their intellectual achievements, the outlook of mankind was extremely circumscribed within a narrow horizon of limited knowledge. An education in broad scientific principles encourages active achievement rather than passive contemplation.

Let us now consider a few examples to show how the biological sciences in general education may be treated in particular relation to their bearing on human problems—the problems of individual and collective living. The concept of organic evolution is of vital importance in emphasising the unity of man with the organic world, the inseparable ties between man and his environment, and the idea of progress and its possibilities. The principles of heredity may require to be dealt with in the first place by reference to laboratory experiments on insects and plants, but they can be immediately applied to heredity as it affects man, particularly in the control of hereditary disease and the improvement of animal stocks and cultivated plants by systematic cross-fertilisation. A knowledge of the principles of genetics is also of prime importance for correcting false theories of racialism which may be propagated for political ends, not only in Germany but elsewhere. Plant physiology is clearly of fundamental importance in its relation to agricultural problems and food production, and can be taught with this end immediately in view. Animal physiology should be taught mainly as human physiology, making use of lower animals only in so far as they are convenient for illustrating general principles. The physiology of nutrition has now come to occupy such a predominant place in a variety of pressing social problems that its importance as an educational subject can hardly be overestimated. An elementary study of the biology of disease may be taught in relation to human ailments as well as to those of the animals and plants on which mankind depends. These subjects are but a few, chosen at random, which might well form part of a general education. Indeed, they are subjects which permeate the day-to-day problems of individual and collective living to such an extent that without some knowledge of them (at least sufficient to permit readily their further study if the need arises) it is no longer possible to develop that comprehensive world-view which the cultured man requires. Excellent and comprehensive syllabuses for teaching biological sciences in general education have in recent years been drawn up by the Science Masters' Association in this country (*The Teaching of General Science*, 1938) and by the Progressive Education Association in America (*Science in General Education*, 1938), and reference should be made to these.

I have urged above that the biological sciences taught in relation to human needs and human problems can provide the incentive to learning which so often seems to be lacking in the earlier educational years. This might be amplified by pointing out that an educational curriculum is successful only so far as it makes use of the natural instinct of curiosity possessed by every child, for in this instinct lies the most powerful motivating force for stimulating the effort to learn. But the instinct of curiosity in the normal child is in the first place always directed towards his own body, his place in the social group, and all those objects of the natural world which so closely affect himself and his fellow-beings. It seems clear, therefore, that this instinct can most readily be converted into an organised process of learning by particular reference to these objectives. Later on it will quite naturally be transferred to more remote objectives as their cultural significance becomes apparent to the developing mind. A child will more readily feel the need for training himself in clarity of expression with the realisation that only by so doing can he follow his other interests with success, than if he is started off with the fundamentals of English grammar and the translation of Latin authors without any reference to the practical requirements of literary style. But the interests of the normal child are not confined to the mere accumulation of factual knowledge concerning himself and his immediate environment. From quite early years he is intensely eager to learn how this knowledge has been attained. This attitude of enquiry and the spontaneous questioning of authority is a natural and healthy sign of the growing human mind; indeed, it is one of the outward manifestations of that intellectual self-possession which is the prerogative of man. I should therefore disagree heartily with the statement made in a review of Sir Richard Livingstone's recent book *Education for a World Adrift* that the 'habit of unreasoning assent and groundless opinion is inevitable in mankind.' On the contrary, this habit is almost certainly instilled by traditional processes of education. The same reviewer makes the remark: 'at what age does the sense of evidence begin to ripen? . . . at that age I should mark the change over from dogmatic to didactic instruction.' But it is surely wrong at any stage in education to impose dogmatic instruction in the sense that facts are presented without indicating how they have been established, and how they can be verified if necessary. In pre-scientific ages the attitude of enquiry was always characteristic of mankind, and if erroneous conclusions and false interpretations of natural phenomena were common, it was because the right methods of pursuing knowledge had not yet been discovered. To-day, the scientific method, involving systematic observation, experimentation, testing of hypotheses, the insistence on verifiable evidence, and the continual re-evaluation of current beliefs, is well established, and there is no possible reason why it should not be introduced into the earlier stages of education. Contrary to the impression which prevails in some circles, the mind of the child and the adolescent is fully capable of understanding and appreciating the principles of the scientific method. Indeed, the sense of evidence is already present in the infant.

To come back to the incentive to learning, the importance for this of a study of the history of science hardly needs emphasis. The story of scientific discovery, taught from this aspect, will not fail to stimulate the imagination and adventurous spirit of the adolescent so that he himself will feel a vivid urge to make his own contribution to the forward march of mankind.

With the introduction of biological sciences into the general educational curriculum, is it

likely that biological problems which intimately affect human society will be more rapidly and satisfactorily solved? Assuredly they will. The conditions of the war have forced into publicity by the increased urgency for their solution numbers of such problems, connected with the raising of crops, animal husbandry, pest control, the physiology of the fighting man, the rôle of nutrition in health, and so forth. It is relatively easy to formulate these problems, and often obvious that they are capable of solution, but one of the main difficulties has been to find enough biologically trained people to work on them. And it is to be noted that many of these problems of war are also problems of peace which should have been solved long ago. There are even social problems whose solution is well known but cannot be put into effect because of the inertia based on public ignorance, an ignorance of which advantage may not infrequently be taken by vested interests. Let me mention one such problem—that of bovine tuberculosis. Every year up to 2,000 people in this country die from this disease, and a much larger number are crippled and suffer distressingly painful operations. Yet it is well known that the disease could to a large extent be eradicated by the compulsory pasteurisation of milk. In view of this plain statement, is it not certain that from an adequately educated public there would arise an outcry so insistent as to compel the appropriate measures to be taken immediately?

The rôle of scientific knowledge in developing powers of aesthetic appreciation is only likely to be questioned by those whose ignorance of science is complete. Aesthetic satisfactions are conditioned by variety and richness of perception and by the development of an ever-widening circle of new relationships, and it is clear, therefore, that the phenomenal growth of scientific knowledge and its increasing impact on human experience must continually enhance the possibilities of aesthetic appreciation. Objects of contemplation which are merely a source of wonder or even indifference to the observer uncultured in scientific knowledge become endowed with rich meanings for those who are intellectually equipped by a general scientific education. From this point of view, the biological sciences, like other sciences, can hardly be excluded from the category of the humanities unless this term is given a meaning which is self-contradictory. Finally, if the 'purpose of general education is to meet the needs of individuals in the basic aspects of living in such a way as to promote the fullest possible realisation of personal potentialities and the most effective participation in a democratic society,'[1] even a superficial acquaintance with the part which the biological sciences are playing in changing the face of our civilisation makes it imperative that they should be regarded as an essential element in any system of education which is to have a cultural value to-day.

W. E. Williams[2]

Discussion Groups in the Army

THIS paper refers only to one aspect of education in the Army. Apart from A.B.C.A. there is in being a flourishing and comprehensive Army Education Scheme which provides regular and expert instruction in a wide variety of subjects. If A.B.C.A. is the sole 'exhibit' in this paper, it is only because it most aptly illustrates the special problem before this meeting, namely, how to instigate and organise the common man's wayward and fitful interest in the world about him.

The Growth of Discussion Groups in the Services.—Within the last year or so there has been a considerable development of the most rudimentary form of adult education, namely, the discussion group. The Army took the lead, mostly under the impetus of the present Secretary of State for War, by making such groups a regular and compulsory item in the soldier's working time-table; the R.A.F. are now organising similar facilities, though not in working time; and, on a much smaller scale and lacking central and systematic direction, some sections of Civil Defence are conducting discussion groups.

How A.B.C.A. works.—The points covered in this paper are founded mainly on experiences of the Army's scheme which is directed and provided by the Army Bureau of Current Affairs (A.B.C.A.). The procedure of A.B.C.A. is simple:—

(*a*) Discussion groups are based on the platoon, the troop, etc., and usually consist of 30 to 40. The leader is a regimental officer—or sometimes an N.C.O.

(*b*) A.B.C.A. issues weekly bulletins to all group leaders containing abundant material marshalled and 'pointed' for discussion. It is the leader's business to digest this material beforehand, and to select from it enough points to promote a useful exchange of opinion and knowledge among his men.

(*c*) A.B.C.A. supplements this provision by a big circulating service of photographic exhibitions, films and other pictorial devices—all of which get direct to troops. It also promotes Current Affairs rooms, Information rooms and similar centres where men can locate and examine facts for themselves.

(*d*) Finally A.B.C.A. organises a network of week-end schools and other short courses where leaders are given a brief but intensely practical training in the art of discussion-group leading.

The Range of A.B.C.A. Discussions.—The set of topics of A.B.C.A. discussions cover a wide field of interest, and the label 'Current Affairs' is given the most liberal interpretation. Thus, apart from discussions of matters of strategy, Empire and world politics, A.B.C.A. has sponsored and directed discussions on public health, food and nutrition, agriculture, town planning, manpower, the colour question, economic warfare, oil, shipping, and paying for the war. The raw material for these discussions, which is published in A.B.C.A.'s weekly bulletins, is not official 'dope' anonymously prepared in the War Office. The authors of the bulletins are independent authorities of high standing, who are completely free to build up the bulletin in their own way. A.B.C.A. provides a preliminary 'Guide to Discussion' in each bulletin, so as to give group leaders a range of approaches in tackling the discussion; but A.B.C.A. in no way dictates the

[1] *Science in General Education.*

[2] Director of the Army Bureau of Current Affairs.

material which the expert provides. This factor has had considerable weight in the Army as a proof that A.B.C.A. is not camouflaged propaganda ; and the integrity of the scheme has evoked a corresponding candour and sincerity in the average platoon discussion.

What are the Discussions like ?—In such a cross-section as the Army provides there is the inevitable wide range of interest and mental capacity. Many A.B.C.A. discussion groups afford lamentable but not surprising evidence of the consequences of cutting-off education at the age of fourteen. Just as we discovered that so many heads were infested with fleas during the evacuation of the children in 1940, so we are finding that there are many empty heads in the Army. At the other end of the scale—notably in Armoured Units, Signals, Pay Corps—there can be found A.B.C.A. discussions of a high order of knowledge and debating capacity. There are similar variations in the skill of regimental officers in leading the discussions. The following generalisations, based on eighteen months of A.B.C.A., can be trusted :—

(*a*) The soldiers are as a rule very keenly interested in the discussions and frequently continue the argument in their own time. Since every effort is made to eliminate the ' parade atmosphere ' from A.B.C.A., the discussions encourage men to speak their minds rather than seek refuge in silence or in agreement with authority. The A.B.C.A. method, as such, has caught on.

(*b*) The most frequent deficiency in the discussions is accurate knowledge. We find again and again that, although there is plenty of common sense, there is a paucity of hard facts. Men will show a zeal and an interest in public health or town planning, but they seldom know much about existing provisions or about the possibilities of improvement. Despite the great extension of such popular sources of knowledge as the magazine, the cinema and the wireless, ignorance of the facts is still enormous. We are nowhere near saturation point yet in the diffusion of popular knowledge.

(*c*) It is notable that the quality of discussion rapidly improves with practice, even under moderate group leadership. The experience of systematic discussion is entirely novel to most soldiers, and for a time A.B.C.A. discussions are as inchoate and irrelevant as the back-chat in a saloon-bar. But the discipline of debate is something which the soldier rapidly learns and seems to welcome. This point is remarked upon over and over again by regimental officers. Their men are neither stupid, nor unbalanced, nor muddle-headed, they are simply unaccustomed to the deliberative nature of an organised discussion. The degree to which the A.B.C.A. is forming good habits of discussion is one of its strongest claims to be providing some elementary education for citizenship.

(*d*) The Army's discussions are usually marked by a vigorous and sometimes violent sense of social purpose. They prefer the topics which come home to their own lives and prospects. Their interest in such themes as the Mediterranean is not so incandescent as their interest in post-war employment, housing, and women in industry. There is no escapist business about this, for they are usually no less keen on talking over many aspects of their own job of soldiering. A.B.C.A.'s easy lessons in the science of strategy, for instance, go down very well. Self-interest—and not on the lowest level—may be regarded as the motive of their concern about current affairs. ' What does it mean to me ? ' is the approach which most quickly rouses their attention and their eloquence.

The Limits of Discussion.—Some enthusiasts have urged us to make A.B.C.A. a daily dose instead of a weekly one. We have resisted that ardour so far, and shall continue to. Apart from the more obvious arguments, such as overdoing a good thing, lack of time and so on, there is the limiting factor touched upon earlier in this paper—that soldiers need to be provided with facts before they can be expected to undertake the digestive process of discussion.

A.B.C.A. is now concentrating, in its second phase, on the job of getting facts across to the troops—and leaving the projection of facts to do its own quiet work. We are using, for instance, a variety of pictorial methods to ambush the ordinary soldier into an interest in science, sociology, history, geography, imperial problems, etc. One device, mentioned earlier, is to provide barrack-rooms, canteens, etc., with not-too-large photographic exhibitions, well laid out, well mounted, and so adroitly captioned as to require no elucidation by a lecturer. These exhibitions are such as a man can absorb at his leisure, at his own rate of penetration, and such as to provide him with at least the ABC of a topic. Of the hundreds now circulating some of the most successful have illustrated cotton, torpedoes, architecture, American industry, the Alaska Highway, planning the countryside, coal, oil, Great Britons, hygiene, planning a house, Russian agriculture, New Guinea, and China.

Another pictorial method of keeping the Army abreast of the facts about current affairs is the *A.B.C.A. Map Review,* which provides each fortnight a coherent synopsis of the news and a graphic annotation of some selected matters of moment. And again, there is the system—now spreading widely throughout the Army—of Current Affairs rooms, Information rooms and A.B.C.A. alcoves : places so strategically chosen that soldiers cannot help seeing them and sampling them. And in these places they can find—according to the zeal and the resources of the unit—maps, charts, wall-newspapers, reference books, lively diagrams and photographs : all the paraphernalia whereby facts can be communicated to the men who are short of them. None of these methods and devices is, of course, new. But what makes their impact so significant is that most soldiers have not previously been exposed to these influences, and that (lacking most of the diversions of civil life) most soldiers are willing to test new kinds of stimulus and interest.

A Permanent Place ?—As a war-time innovation A.B.C.A. has already made a profound effect on the Army. By affording the private soldier an opportunity to speak his mind A.B.C.A. has proved a factor in maintaining healthy morale. When it is wisely conducted, moreover, this regular

weekly discussion has developed a new kind of association between the platoon commander and his men. And, beyond that, A.B.C.A. has provided the Army with a minimum portfolio of facts and ideas on many of the most urgent current affairs. A.B.C.A. is the most primitive and improvised form of adult education imaginable, but it reaches a greater mass of men and women than any organised form of adult education hitherto provided in this country. One question for consideration, therefore, is this : is there, in this A.B.C.A. contrivance, something which may, and should, survive the war ? Something capable of adaptation in peace ? On this matter there are two points to be borne in mind :—

(*a*) A.B.C.A. is done in working hours. Could such discussions be embodied in the time-table of factory life ? The experience of A.B.C.A. suggests very strongly that men and women take the thing more seriously because it is not an extra or an option but as important a part of military training as weapon practice and tactics. If men and women are to see current affairs as part of the texture of working life, then should they not discuss the issues involved slap in the middle of working hours ? The authoritarian states have seen the point of this argument. Is it not as relevant to the democracies ?

(*b*) The Army provides its own group leaders for these discussions. That answer was inevitable, anyway, in so vast a constituency ; but even if it were not, it may nevertheless be the best answer. The expert has his place, but citizens in khaki and out of it are often allergic to the expert and prefer their thoughts to be directed by one of themselves, so long as he is equipped with a bit of something the others have not got.

If there is anything in the foregoing argument about applying A.B.C.A. in civil life, it must also be emphasised that group leaders taken from the same job as the group must be given the kind of training which A.B.C.A. is feverishly, and against all the odds, trying to provide for subalterns and sergeants.

Conclusion.—A.B.C.A. is an improvised experiment in mass-education. Its compulsory nature in the Army has been the least obtrusive element in its application and progress. In less than a year and a half it has developed a popular habit of discussion and has given the troops an understanding of the principles of civic responsibility and systematic discussion. Can this successful experiment in popular education be adapted and consolidated in civil life after the war ? Can the expanding frontiers of adult education be pushed further back still into a territory where the common man's interest in the world remains to be colonised ? These, perhaps, are the most urgent matters for our discussion.

Note

The Chairman urged that consideration should be given by the Council of the Association to the question of maintaining the organisation of the A.B.C.A. (described in the paper by Mr. Williams) or some equivalent after the war, and such consideration has been subsequently undertaken.

Dr. C. H. Waddington

The title of our discussion—Science as a Humanity —is a phrase which immediately provokes the questions : 'What do you mean by science ?' and 'What do you mean by a humanity ?' For we must confess that these two words 'science' and 'humanity' are most usually understood in a sense which makes it legitimate to contrast them rather than to attempt to assimilate them. But I think it is becoming more generally recognised that in taking them in this sense we have drifted into an acceptance of limited concepts of science and the humanities which do justice to neither of these great aspects of man's mental life.

In the narrow sense, science means merely the collection of the particular disciplines—chemistry, physics, zoology, botany, and so on—under which the greater part of the already existing scientific knowledge is conventionally classified. But there is a broader, and a more profound, sense, in which we can take science to mean the type of activity by which this knowledge has been gained. The essential feature of this activity is that it combines reason with experiment. It is sometimes claimed that scientists who attempt to use the word with this broader meaning are laying claim to all the achievements of logical or rational thought. But that is not so. Scientific thought has an essential empirical element, and loses its claim to become scientific when that element becomes submerged—as it became submerged in the scholastic developments of the more scientific legacy of Aristotle, and in many of the eighteenth-century developments of the scientific efflorescence of the seventeenth. No definition of science, however wide, is going to lay claim to the logical subtleties of mediæval theology or the worship of the Goddess Reason.

That does not, of course, imply that science is only an upstart activity of the last few centuries in man's history. It can point to its origins in biological functions at least as ancient as those which underly religion and art. Even in the sub-human world, we can discern a gradual increase in the capacity to take note of the surrounding circumstances (which is the essential feature of empiricism) and to co-ordinate them (which is the essential feature of reason). An amœba reacts to the general conditions of its environment, or, by a localised action, to local peculiarities in actual contact with it. One of the justifications of the phrase 'evolutionary progress' is the observation that very many types of animal have evolved methods of reacting to conditions which are further removed from them and inherently more complicated. Again, the more highly developed animals behave in relation not only to a single feature of their environment, but in response to a co-ordination of such features. They can, in fact, learn lessons about what are to them empirical facts. In a carp coming up for food when the bells ring, in a cat learning to unfasten a door, in a monkey fitting two sticks together to reach a banana, we may see the beginnings of both the subtlety of perception and the co-ordination of data which, in their highest developments, have led to science.

Turning to the other side of our equation, we find that the expression 'the humanities' has also a narrow, conventional sense and a wider, more

profound one. Conventionally it means merely the study of particular literatures, even of particular languages. But fundamentally by the humanities we mean studies of the kind which, coming into vogue with the Renaissance, provided the intellectual basis for the freer and more individualistic civilisation which succeeded the Middle Ages. Originally they comprised mainly the literatures of Greece and Rome ; later there were added to them the great secular literatures of Europe, from Montaigne, Rabelais and Ronsard in France, Bacon and the Elizabethans in England, to the Russian novelists of the last century.

We summed up the character of science, in its general sense, as reason allied to empiricism. If we attempted a similar definition for the humanities, it would have to run something like 'feeling applied to the individual.' But, as was hinted above, the significance of the humanities can only be appreciated when we glance at their historical function.

We may take as the starting-point the classical culture of Greece and Rome : a culture of quick-witted, subtle individualists, interested on the one hand in deep speculative generalisations and on the other in highly practical matters of an empirical nature ; but a culture, one must never forget, of a small minority supported by a large body of slaves who, in the classical heyday, existed materially within the state but spiritually outside the culture. The presence of these excluded men made it impossible for the classical civilisation to place any great value on the individual for his own sake. In fact, as this interest grew among the upper classes, it inevitably tended to spread so as to include the slaves also ; and in doing so it brought the classical age to an end, supplanting it by the mediæval period. This was, indeed, based on a belief in the inherent value of all individuals ; but the extension of the field over which the concept of individuality was applied had been won at the cost of a narrowing of the concept itself. All men were considered important—but important not in this world, where man was a mere cog in the great feudal machine, but primarily as souls to be saved for the next world.

It is the intellectual reaction that ended this state of affairs which crystallised as what we now call the humanities. The movement was allied with the rediscovery of the classical civilisations, but it was also very markedly a reaction against the mediæval view of man as a supremely important soul in the next world but a mere cog in this. In the very early days of the movement, the nascent science of Western Europe played a part only slightly less important than the literary and artistic developments. But science even fell comparatively into the background, and became a mere apanage, even a tool, of the main cultural outlook. From the Renaissance almost to the present day we have seen the development, under the influence of the humanities, of the view that the supremely important thing here on earth is the human individual, not in the slightest as a part of a system, but simply as and for himself. In the economic sphere this leads to the doctrine of free competition, and in the artistic to the psychological novel.

But in the last few decades we have found that free competition leads to 'free' (or at least unrestricted) monopoly ; and the psychological novel becomes more and more a study of the interaction of man and society. The humanistic emphasis on the individual can, it seems, now only engender its dialectical opposite, the feeling of solidarity between members of a society. Those aspects of classical culture in which the Renaissance found inspiration, those European literatures in which the importance of the individual was cultivated, seem likely in the near future to lose their primacy to another view of man which, in some degree returning to the mediæval, sees him as a part of a larger whole.

European civilisation has not yet decided the exact form of the more social view of man to which it seems to be returning. We see, on the one hand, the Fascist striving to integrate man into society at any cost, even at the expense of the more fully developed individuality won during the Renaissance-capitalist period. In opposition to this, we should like to see clearly the development of an outlook which would continue to affirm the value of the individual while at the same time seeing him as a being formed by, and forming, the society of which he is a member. But where shall we find the system of ideas which can be the educational background for such a culture ? There is, it seems to me, no such set of ideas already worked out in West European terms ; the new culture is at the moment of parturition and not yet by any means articulate. (It may be that in the Eurasian civilisation of the Soviet Union the process has already gone further.) But we can, I think, envisage at least one language in which the new cultural outlook could express itself. If the scientific, the rational-empirical, mind were to turn its attention to the broadest aspects of man's nature and life, it would surely conceive of him in a form very similar to that towards which the development of our culture seems to be tending. It is impossible to subject man, as a complete organism and not merely as a composite of physiological mechanisms, to a scientific scrutiny without being confronted with the necessity to consider him both as an individual and as a unit of a society. For example, genetics might be thought of as the science of individuals *par excellence*—but we all know that human genetics leads one almost immediately into problems of the interaction of individual genotypes and the social *milieu* in which they have developed.

The sciences which treat of man as a complete organism have been rather little developed. Human genetics, psychology, sociology, anthropology lag far behind physics, chemistry and even biology in the data they have accumulated and in their theoretical structure. But just as the Renaissance emphasis on the value of the individual began long before the highest flights of the individualistic novel, so the new social outlook will begin to stir long before its theoretical background is fully worked out. It will be the duty of scientists to keep pace with, in fact to keep one pace ahead of, the cultural movement. If they do not do so, the reintegration of society will take place around some other focus. And what other focus is there which can view man always as a social product while at the same time preserving

what was valuable in the emphasis on his individuality? It will be seen that I have not claimed to be able to prove that science, and science alone, can provide us with an adequate point of view. It would be presumptuous to do so while acknowledging that the sciences of humanity are in their infancy. But one may legitimately challenge anyone to produce an alternative.

The view I have been urging, then, envisages science not so much as one of the humanities, but rather as potentially providing a point of view which can succeed that of the humanities as the ideological focus of the new society which is coming into existence. It is suggested that we have passed from a mediæval culture whose cultural sanctions were ultimately religious (derived from the rational-theological aspect of religion) to one whose sanctions were humanistic (dependent on those types of art which cultivate the individual), and that we are now passing into a new culture whose sanctions may be scientific (deriving from the sciences of man). That does not mean that science must 'become the new religion'; any more than art became the religion of the Renaissance. Those three great human activities will of course continue as the three main modes in which man's mind works. What will alter, I suggest, is the order in which man will refer to them when he thinks about himself and his place in nature. As a concrete example of the kind of thing I mean, I may perhaps refer to a recent attempt of mine to show that the scientific study of man can provide a criterion from which the ethical systems of individual men can be judged (*Science and Ethics*, 1942). It was there suggested that the highest duty of man should be to carry forward the main stream of human evolution—an evolution which has so far resulted in the formation of highly complex societies composed of highly differentiated individuals. And in the exposition, the sciences of man were called upon to take the place of the humanities as the mode of approach which led to such a conclusion—just as, previously, the humanities had been substituted for religion when the ideal of 'Liberty, Equality and Fraternity' supplanted that of the soul's salvation.

Underdeveloped though the sciences of man may be, we already know enough about them to realise that an economic system which is congruent with the cultural outlook derived from science will have to be some kind of socialism. In the present chaotic age, political and economic questions are so pressing that some people will be tempted to take the statement that one is advocating a view allied to one of the competing political systems as in fact containing within itself all that is meaningful in the whole discussion. Admit, the socialists will say, that you are on our side, and what is left to be the practical consequences of this 'culture,' this 'scientific view of man,' that you talk about at such length? The answer is that socialism has not arrived yet in our country; and the dominant culture of our society —that is to say, the commonly accepted view of the nature of man—will be a factor both in enabling the political change to occur and in determining which particular variety of socialism will be adopted.

It may be admitted that the sheer pressure of economic dislocations will force some kind of adaptive change in the political set-up. Correlated with this (though it is perhaps premature to assert that it is strictly consequent on it) there will certainly be some alteration in the basic cultural valuations which will make it possible for men to accept the new system. But no one, I take it, will assert that the political change produced by mere economic forces must necessarily be one which preserves, let alone enriches, the human values we have already attained. It will only be so if the political struggle is won by the forces of progress. And one aspect of this struggle is the attempt to formulate a culture which both wins general acceptance and is of a kind which leads towards a progressive system. At present there is no doubt that one of the influences preventing, for many people, the acceptance of a progressive socialist organisation is the apparent conflict between such a society and their deeply rooted cultural outlook which insists on the supreme importance of the single individual. Moreover, even if one has come to admit the general point that some form of socialism is desirable, for which form should one strive—for a strictly egalitarian system, for a Marxist 'class' socialism (and if so, what is the class structure of present-day England?), or for a Beveridge 'welfare' socialism? These are questions which man, however he is driven by economic forces, will have to work out within his own mind. The decision will be taken, partly on the basis of an analysis of what the economic forces actually are, but partly, also, with reference to the cultural outlook and those things which it makes seem valuable. If science can formulate a view of man which, by emphasising once again his essentially social nature, is profounder than that of the individualistic era, it will have played a by no means negligible part in bringing the new society to birth.

Mr. N. F. Sheppard

I SHOULD like to analyse science education (and science as supplied to the public) into several components. They are not independent variables but aspects of a single complex situation.

Section A is the provision of technical information and the training of scientific workers and technicians. We should include domestic science among the applied sciences: its importance is fundamental. The home is the atom of society, and it would be no surprise to find that internal upheavals and readjustments radiated a wide influence. The pivotal question of post-war reconstruction is the ordinary living of the ordinary man. That is where the citizen meets science and has to face problems in applied science most frequently and most urgently. If we are to stimulate public interest in science, that is probably where we should begin.

Section B is the teaching of scientific method and the habit of thinking scientifically. This is essential for everybody.

Section C is the study of the products of scientific work, as part of a general education, and to answer the interested questions of the average intelligent man and woman.

Section D is studying the reactions of our Western civilisation to the recent surge of

technical development, and trying to see in which directions further development should be stimulated in order to preserve a balance and give humanity the maximum benefit and the minimum cause for complaint. This aspect of the work is constantly being discussed whenever scientific workers meet, for example at the conferences of this Association and other scientific bodies. But it concerns a wider public, the historian, the social worker, and those who make laws and decide government policy. It is a study for the adult mind rather than a school subject : it is not a matter which can be learnt once and for all, for it is perpetually changing. But it operates *in vacuo* unless section C has been thoroughly done.

Let us revert to section C. Wherever you are, you cannot look round you without seeing things which have their scientific and technical aspect. The building—the heating—ventilation—or out in the countryside the fields with their crops, the cattle scientifically bred, the birds in the hedges, the sky humming with hurtling machinery. But the central scientific subject of all of these is most often overlooked and is the most important of all. I refer to the human. Science has so much to say about him, and all so important.

Examining man scientifically, we see a gregarious animal with a difference. He is an animal : he must eat and drink, and so forth, and there are better and worse ways of doing these things : science has much to say about each. He is gregarious : he is not satisfied unless he is a social creature, serving humanity and having a place in society : under this heading he may be considered as an ethical being. He is an animal with a difference, like every other animal. Man has developed mentally. When we examine a specimen we find unconscious and semi-conscious reactions, some instinctive and some acquired : we find intelligent thought : we find emotions : and we find something purposive. (Under this heading let us group the will and possibly some much more controversial components.) In some specimens we find these functioning in harmony with one another and with the environment : they then produce a happy and efficient person. In other specimens the reverse is unfortunately the case. Science has much to tell the average man about the way to find this harmony.

Man is purposive. When we analyse our conscious aims to their ultimate elements we find that science can state where the choices lie : it can specify which are irreconcilable and how much each choice will cost in terms of sacrificing other alternatives, but it cannot make the choice for us. That is the function of another aspect of our mental make-up, the ethical or moral or religious. But a man is not functioning satisfactorily unless he has used his intelligence at its best—including the scientific technique—to clarify in this way his responses to the things which he regards as most ultimate and most worthy.

May I give an example of this analysis ? We wish to compare two alternative actions. We consider first the direct consequences in the particular circumstances. Then, those perhaps being equal, we consider possible consequences and their degree of probability, suitably weighted. Then the cumulative effect of many repetitions or similar decisions must be considered : does this statistical view favour one act or the alternative ? And will the habits formed be a help or a hindrance ? And in what direction will it influence the social tradition ?

According to the psychologist no man is complete and healthy unless he has moral or ethical standards which he feels he can trust. The anthropologist shows us the tremendous variety of workable systems of these standards. But since the industrial revolution society has altered so rapidly that the moral and religious leaders have from time to time failed to adjust the details of their teaching. As a result people have to some extent lost faith in their own ethical standards. The consequences have included local and international gangsterdom and war. Scientific consideration of moral problems may not answer the final questions, but it can so clarify them that we can see the choice that lies before us ; science can thus help us to remake our smashed civilisation with faith and with courage.

SCIENCE AND THE PRESS

SUNDAY, MARCH 21 : AFTERNOON SESSION

Address by
Sir Richard Gregory, Bt., F.R.S.
Chairman

News and Views from the Scientific Front

WHEN the programme committee of this Conference invited me to preside at the session on Science and the Press, it was suggested at the same time that the subject of my address should be the foundation and range of the weekly journal of science, *Nature*, with which I was associated, as assistant editor and editor, for forty-five years. To confine attention to a single scientific periodical at a public meeting did not appeal to me, and it seemed more appropriate and less liable to misunderstanding if, instead of surveying the course of *Nature* alone, I dealt with some prominent characteristics of the scientific movement since its foundation ; my contribution to the public understanding of scientific work and thought would be of wider interest and service. These considerations have determined the structure of the address now submitted to this assembly.

Darwin's *Origin of Species* and John Stuart Mill's treatise *On Liberty* appeared in the same year—1859—and the principles of freedom of thought in the fields of natural and social sciences were represented in each of these works in different ways. The basis of Mill's social philosophy was knowledge derived from experience, and the use of reason to arrive at conclusions from personal

observations of facts and relationships. His method was truly scientific, and he applied it to analyse the scope and functions of evidence in logic, wealth in political economy, and politics in representative government. He possessed the true scientific temper in his disinterested love of truth and readiness to revise views when competent authorities had shown them to require correction. He did as much as anyone in his day to widen the domain of science and to subdue to its methods all subjects of human interest.

The works of Mill and of Darwin had great influence in releasing thought from the trammels of conventional authority and revealing relationships between the nature of man and his environment by scientific inquiry. There were strong reactions against the biological and sociological implications of such investigations, particularly because they made the development of both man and society elements of an evolutionary process. Three centuries earlier the earth lost its place as the centre around which all other bodies in the universe revolved, and Galileo was persecuted because he would not desist from proclaiming this truth. To relate man to other living things and assign to him a natural ancestry instead of being a special creation in historic time were even more revolutionary ideas than those which Galileo established by showing that the movements of celestial bodies conformed to the Copernican system.

In the middle of last century contemporary thought was no more ready to receive, or able to understand, Darwin's scientific evidence as to man's place in Nature than philosophers and theologians of Galileo's time were willing to be convinced of the truth of his observations and the rational conclusions derived from them. When the *Origin of Species* was published, the review copy sent to *The Times* was handed to a member of the staff who was responsible for notices of literary works generally. He was an excellent journalist but as innocent of science as a child, so he exercised editorial functions and asked a friend to suggest someone who could write a review which he could adopt with a few introductory remarks of his own. Fortunately, T. H. Huxley undertook to do this, and his fine article on Darwin's book appeared in *The Times* unsigned in the usual way. It was not until later that he permitted it to be known that he was the author of the review.

At that time the *Saturday Review* devoted a fortnightly column to scientific subjects, and this led Huxley to believe that a quarterly magazine surveying advances of science in a systematic way was wanted, particularly on account of the poor state of natural history journalism. He therefore became chiefly responsible for the launching of the *Natural History Review* in January 1861, and continued as its overworked and unpaid editor for two years. He then ceased to contribute to the magazine, but the publisher, John Murray, decided to carry on with paid contributors and editors instead of volunteers. As, however, the enterprise was never sound financially, there was little hope for it under the new scheme, and the magazine came to an end in 1865.

The promise of success of a quarterly review for general scientific readers, whether devoted to the biological or the physical sciences or to both, is no better to-day than it was then. Most scientific and technical societies provide facilities for keeping their members in touch with advances in their own professional spheres, but their vocabularies are usually so highly specialised that they are unintelligible without preliminary acquaintance with their meaning. After the *Natural History Review* had failed to find a sufficient circulation to maintain its publication in quarterly issues, a weekly periodical of a less specialised kind, *The Reader*, was started and Huxley took an active part in conducting it until it also came to an end after a life of three or four years only.

J. Norman Lockyer, who was the science editor of *The Reader* during its existence, as well as a contributor to the *Saturday Review* and other non-professional periodicals, was led by his experience to the conclusion that a weekly journal of science of a more comprehensive scope than any previously published was needed by both scientific and general readers. He was at that time scientific adviser to the Macmillan firm of publishers, and the head of it, Alexander Macmillan, believing that the interests of science and of the British people would be advanced by such a journal, warmly supported plans for its establishment. All the leading contemporary men of science promised active co-operation in Lockyer's scheme, the result being that the first number of *Nature* appeared on Thursday, November 4, 1869, with Messrs. Macmillan as the publishers.

In that period public attention was being directed to scientific subjects in the general Press and other periodicals. A weekly *International Review of Scientific Lectures*, published in Paris, was devoted to public lectures delivered by leading scientific authorities in the chief countries of the world, thus enabling general readers, as well as men of science, to become acquainted with the advances being made. A few weeks before *Nature* was published, John Murray began the issue of the *Academy*, 'a monthly record of literature, learning, science and art.' Professor Huxley and Sir John Lubbock were among the scientific contributors to the first number. Though the *Academy* gave particular prominence to scientific subjects, and included in its second number several papers by Helmholtz, Mayer, Virchow and other men of science read at a meeting of the German Association of Naturalists at Innsbruck, as well as summaries of other communications, it did not become a rival to *Nature*, as was feared it might do, and friendly relations were always maintained between the two editors.

What Lockyer desired to do was to promote public interest in science and its achievements, whether through the general Press, through lectures, or in any other useful way. The more contacts he could find between science and the public mind, the better he was pleased. With Huxley and Tyndall he combined scientific authority with literary power and represented, therefore, the most effective type of connecting link between science and the citizen, whether through articles or in popular lectures. They were not only skilled in the descriptive exposition of scientific knowledge, but also militant advocates of the aims and claims of scientific enquiry in fields in which it was then regarded as an intruder and even now is more often tolerated than

encouraged. It was to assert the rights of science to an honoured place in national service, as well as its responsibilities to the development of natural resources, both intellectual and material, that *Nature* was published.

The objects of the journal were expressed in the following words :—

(1) ' To place before the general public the grand results of scientific work and scientific discovery ; and to urge the claims of science to a more general recognition in education and in daily life.'

(2) ' To aid scientific men themselves, by giving early information of all advances made in any branch of natural knowledge throughout the world, and by affording them an opportunity of discussing the various scientific questions which arise from time to time.'

The establishment of a weekly periodical to promote public understanding of science, and at the same time to provide a forum for natural philosophers, was a notable event in the history of journalism. It is true that, nearly forty years earlier, the British Association was founded with much the same intentions, but as it met in full session only once annually, accounts of its activities in the periodical Press were limited to a few issues. The objects of the Association from the beginning have been :—

' To give a stronger impulse and a more systematic direction to scientific inquiry ; to promote the intercourse of those who cultivate Science in different parts of the British Empire with one another and with foreign philosophers ; to obtain more general attention for the objects of Science and the removal of any disadvantages of a public kind which impede its progress.'

The attitude of the public Press, when the founders of the Association charged themselves with the obligation ' to obtain more general attention for the objects of Science ' and held annual meetings in different parts of the country with this purpose as well as for the discussion of scientific advances, was the reverse of encouraging. It was represented in contemporary journalism by Dickens' articles in *Bentley's Miscellany*, afterwards published as the *Mudfog Papers*. These contributions were caricatures of the proceedings of the first and second meetings of the Association and of the men of science who took part in them. Less crude but just as derisive views as to the meaning of science and its service to the community prevailed in literary circles generally. *The Times* ridiculed the Association and its objects at the beginning and continued to do so for a number of years afterwards. It and other journals of the time, like *The Age* and *John Bull*, regarded the entrance of science into public life as an intrusion, and its efforts to extend the understanding of it as evidence of a desire for self-advertisement.

By the middle of the century, however, contempt had changed to condescension, and the public mind was ready to give sympathetic consideration to the utterances and publications of what had been described as a ' hodge-podge of philosophers ' by such a cultured representative of higher learning as John Keble of Oxford. Even though the tone of literary scholars and leaders of the Press towards scientific work and thought continued to be supercilious, the new humanism made a strong appeal to many progressive minds, and leading organs of the Press introduced its chords into their presentation of news. Then, however, as now, the only reports or comments of any value on scientific operations were those contributed by members of the scientific services or by correspondents competent to observe salient advances and to describe them in untechnical language. In the lack of such knowledge by a reporter or news editor, a message relating to a scientific matter is usually little more than a rumour and belongs to the category of ' If it is true, it isn't new : and if it is new, it isn't true.'

When *Nature* made its first appearance, the period of opposition to organised science and its public relationships had been left behind. From being regarded as presumptively vociferous, the natural sciences came into positions of authority among the progressive elements of human thought and action. The Great Exhibition of 1851, and the second International Exhibition held eleven years later, had given new outlooks to industrial science and its profitable development. Labour asserted its rights to a place in the economic field by the formation in 1864 of the International Working Men's Association, which afterwards became ' The International.' To guardians of traditional learning and social privileges, both science and labour represented revolutionary movements which had to be admitted into the fields of public affairs even though their motives and purposes did not approach the conventional standards of Victorian respectability. The common cause was to secure freedom of thought and action and the advancement of human welfare.

The periodical Press took either hostile or helpful attitudes towards these claims, each reflecting the views of most of its readers and some using a lens instead of a mirror to examine them. In order to exist, a journal, like a human being, must have a good circulation as well as a heart to keep the living stream in full flow. In journalism many hopeful hearts have believed that a large body of the public was waiting to respond to their strong and steady throbbing, but have been doomed to disappointment. Sooner or later, the public, general or special, gets the kind of journal it wants and decides whether or no its publication is worth while financially. From a business point of view, lack of sufficient support is more often due to being in advance of the times than lagging behind them.

In the 'sixties of last century scientific forces formed the spearhead of cultural movement ; but though their main advances compelled attention, they broke up an established system of defence and received, therefore, little support from other elements in the front line. In the absence of accurate and intelligible accounts of operations in scientific fields, neither the public nor its leaders could arrive at a right understanding of their meaning or justly judge the value of the resources of the new territory of natural knowledge. There was need for the organisation of scientific intelligence and also for the expression of scientific opinion upon educational and other public problems then under discussion. The time had come for performance to be related to

progressive policy and science to exert its influence in the realm of the Fourth Estate. It was with the object of presenting news of advances in the expanding field of natural knowledge, and of expressing the views of leaders in the scientific services on contacts of such knowledge with current questions in which it was an important factor, that *Nature* was founded.

No other journal then existed with such a broad outlook on science and its policy in relation to public affairs. The first issue opened with a free translation by Huxley of Goethe's rhapsody on the wonder and mystery of Nature, with appreciative comments upon the permanence of the poet's vision in comparison with the necessarily changing theories of natural philosophers. Among the subjects of descriptive articles in the issue, all of them intelligible to general readers interested in them, were the means by which winter-flowering plants are fertilised ; the total eclipse of the sun of August 7, 1869, and observations made of it in America, including a reproduction of a photograph showing the solar flames ; reviews of prehistoric remains discovered in Denmark, and of British species of moths ; science teaching in schools ; a full account of the scientific researches of the great physicist and chemist, Thomas Graham, who had been Master of the Mint and died on September 16, 1869 ; a description of the meeting of German naturalists and physicians held at Innsbruck in the same month. There was also a communication from an engineer, who had been in charge of the largest canal works in India, replying to critics who held that parts of the course of the Suez Canal, which was formally opened in November 1869, would soon be filled up with debris carried eastward from the Nile and de Lesseps' scheme would prove a failure.

In addition to these and other articles by leading scientific authorities on subjects of wide interest and understanding, the first issue of *Nature* contained summaries of important papers contributed to scientific societies and periodicals at home and abroad. These included notes on the preparation of the chemical element uranium, which has since proved to be the parent of radium ; and the methods of distinguishing between the natural colouring matter of wine and the various substances added to imitate that colour ; relations between cholera and soils and drinking water ; and the emission and transmission of invisible rays similar to rays of light from substances at low temperatures.

On the views side, a leader-note referred with much satisfaction to the offer by Mr. Gladstone of the Bishopric of Exeter to Dr. Frederick Temple, headmaster of Rugby School. Dr. Temple was the first of the seven contributors to the famous volume entitled *Essays and Reviews*, which was published three months after Darwin's *Origin of Species* with the view of reconciling new scientific knowledge of the natural world and its rational interpretations with orthodox elements of religious faith. There was little in the volume to which most educated Protestants would now take exception, yet its publication was strongly resented and the essays were regarded as heresies, if not atheistic.

The storm of protest had become organised persecution of the essayists when Dr. Temple was appointed Bishop of Exeter. Its leader was Samuel Wilberforce, then Bishop of Oxford, whose flippant irony on the subject of man's ancestry led to Huxley's devastating reply at the Oxford meeting of the British Association in 1860. Wilberforce had dealt with the essays in the *Quarterly Review* in the same intransigent manner that he had previously shown towards Darwin's work in the same organ. *Nature* did not intrude into the field of doctrinal disputes thus being extended, but expressed timely appreciation of what Dr. Temple had done for education in science at Rugby. He was the first headmaster to introduce science as an organised part of his school, with laboratories and lecture-rooms properly equipped for instruction in this department of knowledge. It was for this reason, as well as because he was in the van of progressive thought of his time, that his appointment was particularly welcomed in scientific circles. Later, he became Archbishop of Canterbury. His son, the present Archbishop, was born while his father held the See at Exeter, and before being appointed to this high office he also was successively headmaster of a public school, Repton, and held a bishopric, that of Manchester.

Until the publication of the *Origin* and *Essays and Reviews* the pursuit of scientific knowledge was regarded as the recreation of an esoteric group whose interests were intellectually entertaining and educationally instructive and could be used for material profit. Natural science began to be recognised as a social force when it disturbed the calm waters of conventional credulity and rocked some structures in high places at their foundations.

The entrance of scientific usurpers into the fields of public policy and established learning met with a hostile reception, but it was welcomed by enlightened leaders in other cultural groups. The moment was opportune to make their advances and influence known to all who cared to give attention to them, even though the promise of support was relatively small. Confidence in a cause has to be sustained if success is to be achieved, and it was needed to found and maintain a weekly scientific journal in the third quarter of the nineteenth century when education in science had a very minor place in the schools. At that time interest as well as enterprise was required to establish a periodical of this kind. Fortunately, Alexander Macmillan, who was then the head of the great house of publishers bearing his name, possessed these qualities and maintained his faith in the mission of science without consideration of financial profits to be derived from the publication of its weekly message. It was not until towards the end of his life in 1896 that *Nature* became self-supporting, though from the beginning the journal was esteemed as the accredited organ of scientific fact and opinion.

One of the reasons for the long-delayed fulfilment of early promise was the increase of specialisation among scientific workers. In the quarter of a century following 1869, nearly fifty separate societies were founded, each dealing with a particular department of science or technology, all of them issuing publications of a special kind, and some having their own journals. It became difficult to keep in close contact with developments

in even a single field of operations, and more so for workers in other fields to understand the terms in which advances were described. The forces in the front line lost touch with one another, but each continually entered new territory and established strong positions in it. The common purpose of the pioneer corps was to clear away the tangled growth which obscured most of the features of Nature and to explore what was beneath it. The object of the technical services which occupied the territories acquired was to examine the resources in them and apply discoveries to useful ends.

Among the journals in existence before *Nature* made its first appearance were the *Lancet*, *British Medical Journal*, *Chemist and Druggist*, *Electrician*, *Engineer*, *Engineering*, *Gardeners' Chronicle*, *English Mechanics* (now *Mechanics*), and *Pharmaceutical Journal*. A journal which aimed at recording notable movements along the whole line of advance of pure and applied science in terms intelligible to all of them as well as to non-professional readers with wide interests, had to undertake the duties of an intelligence department with the policy of a general staff.

For more than fifty years the scientific staff responsible for the conduct and contents of *Nature* consisted of two officers—an editor and an assistant editor. Correspondents from all parts of the world made the journal a centre of scientific news and views from the very beginning of its foundation. The increase in numbers of scientific and industrial research centres led to a greatly increased volume of original communications from them. The result was that *Nature* became a kind of clearing-house at which scientific drafts were presented and their exchange values adjusted. In a single year before the present war, nearly one thousand letters from original investigators appeared in the correspondence columns of the journal. One-sixth of these letters were from scientific centres outside the British Isles, and thirty different countries were represented by their writers. The journal thus came to be recognised as a world medium in which early announcements could be made of new scientific observations and conclusions.

A notable communication of this kind appeared in the issue of September 29, 1892, when the late Lord Rayleigh described how experiments made by him had shown that the density of nitrogen gas from the atmosphere was greater than that derived from chemical compounds. Sir William Ramsay afterwards became associated with Lord Rayleigh in an enquiry into the nature and cause of the observed difference of density of nitrogen from the two sources, with the result that a new chemical element, argon, was extracted from the atmospheric air. The discovery of this new gas fifty years ago may be said to mark the beginning of a new epoch in the history of the physical sciences. It was followed two years later by Sir William Ramsay's announcement in *Nature* that a gas which he had extracted from the mineral cleveite had been identified by Sir William Crookes as the element helium, previously unknown on the earth.

Twenty-seven years before this specimen of helium was obtained from a terrestrial mineral, Sir Norman Lockyer had found it in the sun. While investigating the gases present in the flame-like eruptions around the sun, he could not identify one of the bright constituents of their light, and he gave the name helium to this cryptic gas. It was most appropriate, therefore, that the discovery of terrestrial origins of the gas should have been announced in the scientific journal of which he was then the editor. Helium, like argon and neon, now extracted in large quantities as by-products of liquid air, has proved of great industrial value. Argon is widely used in gas-filled electric filament lamps and thermionic valves, and neon in electric discharge tubes for advertisement and other purposes of effective illumination.

Though the discovery of new gases in the air and the extraction of helium from terrestrial sources were of great scientific importance, neither of these advances of knowledge was first-line news in the public Press. The discovery by Röntgen, in the autumn of the same year in which helium had been isolated, of a new kind of rays which penetrated opaque substances and made it possible to see and to photograph the bones of the human body naturally excited much wider interest. Newspaper correspondents in Germany reported this news early in the year 1896 and a translation of Röntgen's paper describing his X-rays appeared in the issue of *Nature* of January 23. The translation gave the complete text of the paper, as well as reproductions of the photographs included in it. This gave the first authoritative particulars of the discovery made in the British Press. To the same issue the late Mr. Campbell Swinton contributed a descriptive article upon experiments which led to it and the first photographs of a living human hand taken in England with the same form of Crookes' tube as had been used by Röntgen. As a point of historic interest it is worth mention here that, in *Nature* of June 18, 1908, Mr. Campbell Swinton suggested how the cathode rays produced in such a tube might be used for distant electric vision. Not until twenty-two years later was this principle put into practice in an effectual system of television.

A year after the discovery of the penetrating properties of X-rays it was found that rays of a similar type were emitted by compounds of the chemical element uranium. Four years later the wonderful element radium was extracted from pitchblende by Mme. Curie. It and other substances were found continually to emit a peculiar emanation, or gaseous form of radioactive matter, which had remarkable physical and biological properties. It was proved that they were all slowly disintegrating and as they broke up gave rise to three types of radiation ; namely X-rays, particles called electrons charged with negative electricity, and particles charged with positive electricity identical with the nuclei of atoms of helium gas.

In themselves these and similar results of experiments carried on towards the end of last century claimed predominant attention in scientific societies and periodicals, and they introduced a new era of atomic physics. Radio-communication and broadcasting are applications of principles of electronic and thermionic effects then established. The general public could appreciate

these developments and make intelligent use of the instrumental equipment required for their service without understanding the principles involved in their construction. On this account, and particularly because of the destructive weapons of warfare derived from progressive natural knowledge and invention, science again came to be regarded not so much as a benefactor to the human race as a disturber of the peace and a demoralising influence. In the middle of the last century, science came into the field of public discussion because it presented conclusions as to the evolution of mankind which could be debated without special knowledge. Fifty years later, the results of discoveries in the realm of the physical sciences were claiming public attention because of their contacts with everyday life.

It is when knowledge is found to be of practical service that its public value is appreciated. When the Augustinian Abbot, G. J. Mendel, published his experiments on the hybridisation of peas and other plants in the 'sixties of last century, no one realised that his discoveries marked a new epoch in the history of pure and applied biology. It was not until the beginning of the present century that his two papers were excavated from the records of the local society in which they had been buried and found to be the Rosetta Stone by which the intricate characters of heredity could be interpreted. Mendelian principles are now the basis of scientifically guided plant and animal breeding, and their applications in the production of livestock and crops with desirable qualities have greatly extended the range of control of farming and horticultural industries.

By providing the means of expansion of old industries and creating new, science has transformed conditions of civilised life and influenced the whole social structure. In Darwin's days beams from strong scientific search-lights revealed weak parts of ancient bulwarks which were believed to be impregnable. The beams came from a lighthouse and were not produced for purposes of aggressive action by new forces but for the guidance of mariners in mysterious seas. They were, however, so dazzling in their effects that they were resented as a danger to established principles of navigation instead of being welcomed. The conflict which then arose was between champions of new and old ways of looking upon human life in its philosophic and spiritual aspects. Later, the cry of danger was again raised against science because poison gases, high explosives, and bombs from airplanes were among its fruits. The war of 1914–18 brought this attitude towards science into prominence, and the view was expressed by disturbed leaders of thought that a halt should be called to further advance of knowledge because of the dehumanising results which might be derived from them. By this time, however, there was a sufficient body of responsible opinion to assert the right of science not only to liberty of thought and action in its own fields, but also to be a component part of the executive staffs in control of the disposition of its forces.

The campaign with these objects in view as well as to establish closer contacts between science and other formative elements in the social structure, was opened in *Nature* of October 21, 1915, with a leading article on ' Science in National Affairs.' Every week since then the journal has had the temerity to express opinions upon current affairs in which scientific methods and services are involved. Without entering the field of party politics there has never been a lack of important public problems requiring scientific knowledge as well as wisdom for their right solution. The result of the revival of the scientific movement has been to give the social and international relations of science both shape and policy. In 1938 the British Association approved the establishment of a division of its constitution to promote these objects, which were among its original purposes. There are still many people who regard scientists as members of a kind of monastic order content to carry on their studies in cloistered seclusion, whether their lives and work are of service to others or not. The history of science is rich in examples of men of this type pursuing knowledge for its own sake without thought of recognition in this world or reward in another. They are the saints of science and are revered as such by all who esteem truth and the high endeavour its pursuit entails. To these natural philosophers the impressive fabric of science owes the main features of its design and execution ; and no tribute is too great to be paid to them.

Science is, however, a gospel of righteous principles, however much they may be departed from in practice. It has the duty not only of preparing messages but also the mission of interpreting their meaning to all who will give attention to them. In the history of civilisation there has never been an epoch in which understanding of the spirit and service of science was more necessary for the public and its leaders than now. A century ago wide public interest was aroused in scientific subjects through descriptive lectures with experimental and other illustrations, but there is far less demand in these days for the expositions which were then so popular. The cinema and broadcasting can now perform this informative function much more effectively than peripatetic lecturers. What the public is ready to take active interest in to-day is the impact of science upon social conditions, and its relations to life and labour. These are subjects upon which any individual citizen affected by them can have his own opinion and is at liberty to express it. The function of science at a public conference or meeting is to present the results of impartial enquiry into any such subject for which a meeting is convened and to provide whatever further information is available relating to it.

The British Association, through its Division for the Social and International Relations of Science, could most appropriately organise such public conferences at suitable centres anywhere in Great Britain, and by doing so would greatly assist in the extension of knowledge of contacts between the natural and the social sciences. It could do at home what the British Council is doing for science and other fields of culture abroad, but to undertake such an educational enterprise successfully would require much greater financial support than the Association is at present able to provide. If this Conference on Science and the Citizen should lead to the establishment of a kind of public university extension movement, with particular reference to science

and social values, it would mark the beginning of a new era of constructive co-ordination of progressive scientific knowledge with changing social needs.

Henry Martin

My aim is to discuss how science and the press, having settled their own relationship, may co-operate for the benefit of the citizen. Both have up to now resembled next-door neighbours who are not on speaking terms because they have never been properly introduced. Mutual prejudice is based on ignorance of respective qualities and potentialities. Reconstruction will offer them the opportunity of shaking hands.

After the war there will be world-wide interest in the scientific achievements which for security reasons have had to be kept secret but will become available for peace-time adaptation. In order to satisfy that genuine curiosity and desire for knowledge the press will expect an unstinted supply of accurate information. Editors may decide to establish a regular science feature as part of a scheme of post-war enterprise in which I predict that an extension of magazine articles with illustrations will figure. Why not appoint a science correspondent and add him to the growing list which already comprises labour and industrial, food, agricultural, military, naval, air, diplomatic and political correspondents? Should I discern the beginnings of a market in the provinces—I feel sure that there will be one and shall take steps to encourage it—we shall not hesitate to offer a weekly article over the Press Association network of wires, which are linked with no fewer than a hundred and twenty evening and morning newspapers. Where the information will not wait it will be issued, as now, in the regular news service. From evening newspapers certainly a warm response may be looked for, and morning papers will not lag behind.

Science and the daily press may not appear to have anything in common. Experience would seem to indicate almost mutual repulsion. Yet they meet, if nowhere else, on the common ground of detachment. Science gives the impression of living in insulated seclusion: the press is detached in another way. Viewing the cavalcade of life, and always in a hurry to record the panorama of events, it has somehow unconsciously transformed itself, at least as far as some aspects are concerned, into a ghostly spectator. The public needs both scientists who are complete men, not escapists, and the responsible, intellectual (not only intelligent) journalist; and the need should draw the two together. The reactionaries should be persuaded or educated to re-direct their energies. In the case of journalism the lead should undoubtedly come from the top.

What so far has been the experience of the press? An editor reads that a discovery has been made. He happens to be genuinely interested and sends a reporter to secure details. Perhaps the expert concerned has suffered inconvenience through once having, as he considers, been misreported. So he either refuses to see the reporter or indicates that at the moment there is nothing definite to disclose, or he may be too busy and fail to realise that a man in A.D. 1943 cannot live unto himself.

The way of the journalist seeking scientific truth is hard and disheartening. He is groping all the time. Yet he is patient and long-suffering and, unlike Pilate, is prepared to wait for an answer. Frequently his difficulty lies in knowing whom to approach. Library references yield the names of some of those who can speak with authority on a particular subject, but these individuals may not be easily accessible and even, if found, may be disinclined to talk. Time, money and energy can be wasted in exhausting a list of persons without result.

Knowledge has no central temple of its own in London, no high priest to whom a press enquirer may turn for guidance and not go empty away. There is no common pool fed by the tributaries of learning.

The numerous papers read before learned societies in times of peace present a fairly large potential field of information. Some, it is true, are so technical as to baffle the journalist. If an address is intended for experts only, no useful purpose is to be served in trying to popularise it. Sometimes a thoughtful secretary posts a synopsis, but his idea of what he thinks the press wants and what it actually can make use of are very different. A second type of paper is more or less straightforward and offers no difficulty in handling for press purposes. Between the two is the border-line case. One journalist may decide to leave well alone, while a colleague, more tenacious, has a shrewd idea that if he could obtain the key he could turn the paper into a short and interesting exposition calculated to produce medium-sized headlines.

The approach to and investigation of scientific matters by the daily newspaper journalist are on an unsatisfactory basis. In fact, there is no basis at all. It is for science, if it be in earnest about its avowed duty to mankind—and I have no doubt of it—to rouse from its apathy or indifference and take the first step towards a rapprochement. The onus will then be on the press to respond so that neither may penalise the citizen whose interests they both wish to serve.

Science must be prepared, indeed eager, to supply the press with accurate information. It will then have definitely set out to gain the confidence of the public, which at present is inclined to regard it as a haughty, highbrow stranger. Already some useful free-lance work has been done. Ten or twelve years ago the Central Council for Health Education consulted me, with the result that every week I issued to newspapers on its behalf articles under the signature of influential doctors. The press response all over the country was surprising and gratifying to the Council. When I was in New York at the end of 1934 I met the science editor of the Associated Press, a great news agency from which the newspapers of the United States, then numbering nearly fifteen hundred, derive the bulk of their news supply. From small beginnings he had been extraordinarily successful in establishing a science News Service. He had overcome distrust and derision; the scepticism of individual scientists and of learned societies had turned into confidence; and he collected and collated from many sources material from which, with enthusiasm, he prepared articles in a form suitable for an

intelligent reader. The war has not interfered with the feature. These articles are regarded as authoritative.

Since the war began Mr. J. G. Crowther has edited on behalf of the Science Committee of the British Council, of which Sir Henry Dale, President of the Royal Society, is chairman, a budget of information entitled " Monthly Science News." Its primary intention is British propaganda overseas, but in view of my interest the British Council was good enough to allow me to select items and issue them to the Press of the British Isles. Another promising step has been taken by the Chief Medical Officer of the Ministry of Health, who during the war has been holding press conferences at regular intervals. The educative information supplied by him and distributed by the Press Association has received the widest publicity. When the Ministry desired to draw public attention to the alarming increase in the incidence of venereal disease it was my organisation that was the main medium of distribution. Here was an example of wise co-operation with the Press.

The Ministry of Information has a Press Bureau, from which emanates a daily stream of communiqués and other messages bearing on the war. To this central source Government departments send their announcements, and advance copies of speeches by leading public persons also are issued. Everything is done to assist the press in the collection of news. The News Division answers innumerable enquiries, organises visits to forces and factories, arranges interviews and background conferences with all sorts of important people, including highly-placed visitors from Allied countries, and has formed a reference library for the benefit of journalists.

What science needs to consider is a press bureau for the collection, collation and dissemination of scientific information, with offices near or preferably in Fleet Street. That is if it seriously wishes to make the nation healthier and happier because knowledgeable and to utilise the press as one of the chief auxiliaries. Such a bureau should have international ramifications, contacts in the foreign capitals, so as to permit of interchange of information and rapid and frequent consultation. Each bureau abroad would, just as in London, be responsible for organising the collection of science news in its own territory. No doubt some benevolent trust could be approached to furnish a substantial endowment to inaugurate a centre on a modest scale to begin with and to provide a maintenance income.

The press bureau would need a director, together with an editor or a news editor and a small staff of men with both journalistic and scientific qualifications—men with a practical knowledge of newspaper needs and technique and with a catholic interest in and knowledge of science combined with a capacity for assimilating material in the raw and turning it into simple language for publication in the daily press. A reference library would of necessity be built up. The director should be well known to and *persona grata* with the world of science and those connected with it. One of his first duties would be to link up with them and secure general support for the scheme. He would form panels of experts who could be accessible at any time and asked, in return for a fee, to provide the latest information of research or discovery on their own subject or answer questions about it. This information would be prepared for the press as a whole or passed on exclusively to the newspaper which had originated the enquiry and which would, it is to be hoped, be prepared to meet the cost. News so often comes in from home or foreign sources upon which an authoritative expression of opinion, given the same day, would be welcome. The keynote of the bureau, in fact, would be initiative, represented by a steady flow of digested matter in a form suitable for publication.

The director's work would extend to newspapers all over the country, the editors of which he would encourage to make use of the bureau. He should make a tour of the newspaper offices, requesting co-operation in educating the public. He would discuss with editors newspaper production problems and ask them to look benevolently upon science news ; to publish regular articles ; not to remove an article or a paragraph after a first edition should its intrinsic interest warrant attention ; to impress upon staffs the wisdom of treating such news soberly rather than sensationally ; and to give even the seemingly dull stuff a chance. Newspapers are prone to under-estimate the standard of intelligence of readers.

A wise director would note the quiet, but solid influence of the weeklies, especially in rural homes. He would get to know London editors and news editors as well as the London representatives of the provincial press whose head offices he had already visited. He would lose no time in securing the goodwill of the great news agencies in the knowledge that their power of infiltration is unsurpassed and that they are the backbone of the daily press. He would assess the opportunities offered through the Press Association, which by teleprinter and Creed Wheatstone supplies by high speed transmission close upon 150 morning, evening and Sunday newspapers in and outside London in addition to the news agencies of the five continents represented in its Fleet Street home. He would see for himself how Reuter slips a radio girdle around the globe with important home news which newspaper subscribers at every point of the compass pick up for publication.

Once a fortnight or every month conferences of journalists might be called to hear a survey of the scientific field and to meet some of the scientists. Certain information could be given in confidence, other information for publication on an agreed date. The press would learn, too, of forthcoming events and discuss plans for handling them. Wide publicity demands a technique in handling. Papers to be read either at independent meetings of societies or in a joint conference such as the British Association annual gathering would be collected by the press bureau, synopses prepared and their significance explained. The presence at these press conferences of science correspondents would be preferable, for if the ordinary reporter were sent he would probably be a different man or woman on each occasion and be tempted to seek something out of the way for next day's paper. This would not, however, prevent a news

editor from sending any reporter whom he might have available to make enquiries if the science correspondent did not happen to be on the spot to ascertain the value of a suddenly-arising piece of news. Science correspondents and any accredited journalist should be invited to drop in at any time and consult the staff. Guidance on the line to be taken in a story would be most useful. If a newspaper required special information the press bureau would if necessary extend its range of inquiry to a telephone call (say) to New York or to Moscow to speak to one of the experts on the American or Russian panel.

I suggest that science, through its press bureau, might also open up an even richer field than now in the magazines and periodicals. Nor should the photographic side be neglected. The director might follow the example of the military, naval, air and civilian authorities during the war and arrange press visits to centres of research, laboratories, etc. In the event of the announcement of an outstanding discovery it would be more profitable to arrange a mass interview with the scientist concerned than allow him to be subjected to separate press bombardments. In many other ways known to journalists the bureau could prove of assistance. I am sure that its development would be sound and healthy and that science and the Press would soon be established on a firm footing of understanding and mutual confidence.

It would be unwise, however, for science to dictate the manner in which the information imparted should be treated in newspaper columns. The Press must be left its freedom and as a measure of reciprocity would undoubtedly realise its obligation to publish on serious responsible lines. At the same time there must be some agreement to protect the form and substance of any statement made by a scientist under his own name. It must not be open to misunderstanding direct or implied by reason of its juxtaposition to matter written by the journalist himself in conformity with the style adopted by his newspaper.

Let me in conclusion disclaim any intention of trying to foist upon science blame for some of the mistakes due to sheer ignorance that are apt to pass undetected through several hands into newspaper columns. It will be for the journalistic profession to ensure that entrants possess a much higher standard than at present of general knowledge, of cultural attainment or promise.

Francis Williams

We have to consider how far the Press can be an instrument for popular education in the social significance of the achievements and potentialities of science.

What is clearly desirable is not simply occasional publicity for outstanding scientific achievements, written up because they are of sensational or outstanding news value, but a consistent interpretation to the public of the social impact of scientific developments upon the world, and the place such developments can and should play in determining national and international policies.

No less desirable is the inducing of a scientific attitude—in the broadest sense—among the public in considering political, social and economic problems. The satisfactory democratic solution of a great number of the problems of how men and nations are to live peaceably and prosperously together depends upon our capacity to lift a wide range of social, economic and racial problems out of the realm of conflicting prejudice into that of objective scientific enquiry.

We must ask ourselves (*a*) whether the Press can help in this, and (*b*) whether it is likely to be willing to do so. Before we can answer these questions we must examine the structure of the Press and its purpose as conceived by those responsible for it.

To do this we must consider the changes in the structure of the Press resulting from the rise of the national paper with large circulation, the further changes brought about or likely to be brought about by the war, the economic basis of the newspaper industry, the distinction between 'quality' newspapers and 'popular' newspapers, and the part played in the editorial selection of news and features by the attempt to assess the largest common denominator of public interest.

Since modern newspapers are commercial undertakings, dependent upon revenue from advertising and sales, they cannot go far in advance of the educational level and interests of the mass public. They are an educational influence, but only at second remove. They have to satisfy existing demands, and the nature of those demands depends largely upon the kind of citizen the educational system has produced.

What possibilities are there of a new technique for the presentation of serious matters so that they will capture the intelligent sustained interest of the public? It is the duty of scientists, newspapers and schools to work together without delay in considering this urgent problem.

Dr. D. S. Evans

The Exposition of Popular Science

The subject of the social relations of science has interested scientists ever since they were presented, on the one hand, with the spectacle of the frustration of science in the capitalist countries, and more especially with the waste and misuse of science that accompanied the great depression; and, on the other hand, with the demonstration in the Soviet Union of the way in which scientific and technical knowledge could be utilised for the progress of civilisation.

The time has now come when every scientist must realise how his work is related to social and economic conditions. It is clear that, as much as any class of workers, it will be the scientists who will supply the technical means of victory, and it is even more evident that reconstruction, if it is to be successful and permanent, must be built within such a social framework that it is able to give to the community the full benefits which accrue from the work of the scientist.

The social relations of science cannot therefore be confined to the essential—but, nevertheless, slightly academic—study of the relations between the development of economic history and the progress of science during past epochs. We are faced here and now with urgent problems, and it requires no gift of prophecy to see that in the very near future situations of even greater acuteness, for which we must now prepare, are likely to arise. We must make our work in the field of the

social relations of science a living force of immediate effectiveness and value.

The most pressing need is for the better utilisation of science in the war effort, and for the provision of organisational means for the optimum employment of the scientific men and the scientific knowledge which we now possess.

The problem of the full utilisation of scientific personnel and knowledge in the future is a second problem which cannot be divorced from immediate issues. Its solution is to some extent already being determined by organisational changes and new conceptions which have grown up in response to war conditions, but the deciding factors will be essentially political. In that period of political and social unrest which will set in as soon as the end of the war is within sight, various forms of political and social organisation will be offered for the consideration of the people by this interest or that. The form which gains acceptance will be the most important factor in determining the eventual status of science in the community. Moreover, the arguments which are advanced in support of these rival systems of society will—in so far as a modern state cannot dispense with scientific and technical resources—be supported by a variety of technical considerations whose validity can only be estimated in the light of scientific knowledge.

The key to this situation is thus going to be the opinion of the mass of the people, and if we wish to prevent a repetition of the situation in the 'thirties, when science was largely unused, neglected or perverted, we must bring home the realisation of the potentialities of science not only to scientists, but to the ordinary man in the street.

The essence of popular science is therefore propaganda, frankly political in the wider sense, and using as its material the most exciting and revolutionary doctrine ever propounded, namely objective truth. The objects of that propaganda must be, first, to show the general public what science can achieve in their service for the maintenance, reconstruction and improvement of civilisation. Secondly, we must endeavour to give them some protection against those who, for one reason or another, find it in their interest to advertise the wares they have to sell with pseudo-scientific arguments, whether those wares be a recipe for the prediction of the future, a nostrum to cure all diseases, or a bogus system of government. Thirdly, the object of our propaganda should be so to set out the elementary method of thinking which we call the scientific method, that we may succeed in fostering the habit of critical and logical thinking on all kinds of technical and social problems.

That these objects can be achieved is evidenced by the very different attitude towards science which is to be found in the United States and the Soviet Union as compared with that which obtains here. Let us not imagine, however, that they are objects which can be achieved without struggle not only against apathy, but against active opposition. If we miss the political and social significance of our work, our opponents certainly do not, for they know that the fullest implementation of the resources of science for the benefit of the community can only be achieved by far-reaching social changes.

The attitude of the public towards science is curiously paradoxical, for it is at once a combination of uncritical reverence for something not properly understood, and a distrust of the results of science, which is blamed for all the technical horror of modern war. But there is another feature of the popular attitude towards science which is of the greatest significance. In recent years it has expressed itself particularly in the incidence of newspaper astrology. I think that we ought not to see in this merely the perversion of a genuine science, but that we ought to regard it as a symptom of a mental state in which the public mind is confused, unwilling or unable to rely on logical thinking for the solution of its problems. Under such conditions it is possible to persuade large numbers of people to follow any strong lead, and it is up to us to see that that lead is not directed as it was in Germany.

We have chosen the word propaganda—in spite of its many evil associations—to describe the type of popular science which it is necessary to undertake. How does science as propaganda differ from the kind of popular science to which we have been accustomed?

Propaganda is the constant illumination and repetition of certain fundamental ideas through a great variety of examples. No one can undertake propaganda unless he or she thoroughly understands the fundamental concepts which are to be presented, and can return to them ever and anon by various routes, each of which leads finally to the same lesson. Moreover, propaganda must be realistic and related to the ordinary life of the consumer. Thus if we wish to bring home the potentialities of science to the ordinary worker, we may start from the background of his home or his place of work, showing how science is applied there and how its applications could be extended and improved. For instance, we might envisage the mother of a family, worried by rent and the illness of a child. To her we can speak not only of labour-saving devices and of better housing, but of diphtheria inoculation, hygiene, and balanced feeding. To her husband we can bring home the science behind his work in the factory, the facts of industrial diseases, the metallurgy of alloys, factory lighting, and so on. As propagandists of science we shall rarely try to disseminate detailed scientific facts for their own sake to the general mass of the people, but we shall always try to relate them to live issues of general interest. At this point I wish to make it clear that I do not regard this as true of all popular science. For special audiences more detailed treatment is desirable, but for a general audience such an approach would have little effect, and would in any case miss the most important object of all, that is, of making science a living and important reality for the general mass of the people.

To them our propaganda must consist of a series of messages, each driving home one single important point; it must, if it is to be effective, be repetitive, and it must be of an adequate volume. Moreover, it must be presented to the consumer without any special effort on his part. All these considerations have been at the back of the campaigns which in this country have made 'Beer is Best' and 'Player's Please' phrases which everyone knows. The reverse side of the medal is that

the same technique of propaganda was used in Germany to make ' Heil Hitler ' equally familiar.

To make use of the same methods to produce a positive benefit we must learn from these examples. I have already referred to the fact that in the 'thirties the realisation of the frustration of science became widespread among scientists as the result of the books written by a few pioneers. Without wishing to decry the enormous value of this work, I think it is true to say that they lacked propaganda value of themselves, simply because a man buys a book only when the title already interests him. Thus books are not the primary medium of propaganda, first because their circulation is comparatively limited, and secondly because their appeal is mainly to the initiated.

If we are to tackle the problem of the fullest utilisation of science on an adequate scale, we must do this through the primary media of propaganda—the press, the radio, and the film. All these satisfy the essential requirements that they are adequate in volume and that they are presented to the consumer, either at no effort on his part, or as the result of an effort—such as buying a newspaper—which he makes for quite other reasons.

The British Press presents a peculiar problem to the intending publicist of science, and the difficulties are especially aggravated in war time.

The national Press has a very limited space at its disposal, which it reserves for hot news, and especially news directly connected with the war. Science comes off rather badly in this respect, and the stories printed usually concern some new weapon or war instrument, such as radiolocation.

The great difficulty is the actual structure of the national Press, which consists of a comparatively small number of journals all competing for the same market, so that syndication of scientific news and features would present a far more difficult problem here than it does in the United States, where there are no newspapers which have a nation-wide circulation.

These two factors have meant that scientific stories have been confined to really big developments which, like radiolocation, can command sufficient space to enable a certain amount of technical explanation to be given, or to short factual stories, concerning which it is apparently held that the public have already sufficient knowledge to make the inclusion of background information unnecessary.

The provincial Press presents a very different picture. Here there is little or no interspecific competition, so that syndication or re-using of the same material in different parts of the country becomes a practical possibility. In addition, I believe that the provincial newspaper, and especially the local weekly, is read with far more care and attention than is accorded to the national morning newspaper. Its space, though full, is probably less heavily loaded than that of the national newspaper, and its copy deals with topics of more local interest.

In many ways our provincial newspapers correspond to the very much larger newspapers of the cities of the United States.

It was for these reasons that when, almost two years ago, I suggested to the Association of Scientific Workers that some effort should be made to carry out a practical scheme for the dissemination of science, our first efforts were directed towards the provincial Press. At that time the Association was already sufficiently large and its branches sufficiently widespread to enable us to operate such a scheme with a reasonable prospect of success. Groups of people interested in the work have been set up in a large number of branches, and many of them have succeeded in persuading the editors of their local newspapers to publish regular scientific features, starting with those which have the greatest immediate relevance to everyday life.

This work has enjoyed a considerable success. I believe that we are beginning to show to certain sections of the public that science is interesting and important to them. I also think that we need only to double our present output of such scientific features to ensure that we shall be actually gaining on the astrologers, race theorists, anti-vivisectionists and what not who have such large resources of propaganda at their disposal.

Our experience of the last two years has taught us much. Perhaps the most important lesson has been that popular science exposition is a highly technical subject, worthy of scientific study, and that in some ways a scientific training is the worst possible preliminary. The scientist writes his papers beginning with his premises, and working up to his grand conclusion. The journalist writes in exactly the opposite way. He has to catch the attention of his audience at once, against competition of various kinds. He puts his most interesting conclusion first. I often think that the fact that so many scientists only read the summaries of papers should encourage us to learn a little of the journalist's craft for our purely scientific writing.

The greatest mistake which we can make in this field is to adopt a superior attitude towards the journalist, to belittle the technical requirements of his craft, and to regard ourselves as superior beings. If we hope to achieve an amicable symbiosis with the journalistic world, we must at all times try to understand the requirements of their profession, and we must estimate that profession as no less technical and difficult to master than our own.

After about a year of working, the deficiencies of the scientist as a writer became apparent, and we therefore held a one-day school in London, at which we tried to demonstrate, with the assistance of experts, the technical requirements of this type of writing. It also provided an excellent opportunity for the discussion of a host of practical difficulties which had turned up in various localities. It was something like an embryo meeting of a guild of science writers, and in fact I consider that we have advanced so far that we might well begin to consider the formation of such a guild in Britain.

It is interesting to analyse the reasons for such success as we have achieved. The first is that those concerned have a very clear idea of the objects of the work. Secondly, they are sufficiently numerous to enable us to establish regular working contact with the press over a wide field. Lastly, our branch organisation enables us to establish a series of groups, rather than isolated individuals, who can bring a wide variety of

technical knowledge to bear in each area, and can avoid mistakes and gain encouragement by mutual discussion.

In conclusion I would emphasise once more that this is an urgent political matter : that if we are to secure a victory and an effective reconstruction based on the full employment of our technical resources, there must be a tremendous heightening of popular understanding and criticism of technical matters. As scientists we must organise ourselves so as to foster that criticism, and to encourage the public to think with their heads and not with their blood. The penalty for failure is clear. If you begin by thinking with your blood you end by wading in it.

I would therefore put before you the conception not of popular science but of a *people's* science, in which science is an integral part of the cultural life, the administration and the government of this land.

Ritchie Calder

A Plan for an Institute of Scientific Information

In the newspaper world before the war, the average journalist had as low an opinion of the average reader as the average scientist had of the average journalist. The ' average reader,' we were told, was interested only in crime, in dog racing, in football, in film stars' love affairs and in Mayfair gossip. He was not interested in science unless science could produce sensational headlines—a death ray, a new elixir, vitamins that would make footballers score more goals, and so on. The scientist to the ' average reader ' was someone remote and unintelligible who talked a gibberish and, like a malevolent spirit, created unemployment and the instruments of war. Under the tyranny of this entirely imaginary ' average reader,' newspapers exploited science but never explained it.

As a journalist, I disagreed with this moronic conception of the ' average reader,' and refused to be intimidated either by science or by scientists. When, ten years ago, the popular newspaper on which I worked decided to make science a regular feature, we treated science seriously and, I think, with a sense of responsibility. One of the greatest difficulties was to break down the dislike and suspicion of the scientist for the journalist.

The scientist was, quite properly, jealous of his reputation and scared of flamboyant headlines and sensational misinterpretations. Even when he was guaranteed against those, there still remained his supreme contempt for what he called ' popularisation ' : that was sheer snobbery or a confession of his own illiteracy ; because he himself could not make himself understood to anyone outside the small and select group of specialists in his own subject, he assumed that the subject would be degraded if it were made comprehensible. One eminent physicist, whom I was trying to coax into articulateness, impatiently tore out a page of his notebook covered with the scientific cryptograms of his latest experiment and said, ' All right. Go and produce an article out of that.' Whereupon I tore a page out of my notebook covered with shorthand hieroglyphics and said, ' I will, if you will deliver your next lecture from that. I do not expect you to understand my shorthand until I translate it. Why should you expect me to understand yours ? ' He capitulated and my readers got a simple and highly interesting exposition of his notes. His students did not get the benefit of mine ; which was a pity, because it was the verbatim of a particularly colourful passage of an address by George Bernard Shaw to the World League for Sexual Reform.

I was not always successful. On one occasion I spent hours with a research worker who had been engaged for seven years on a particular piece of research. He was anxious to be helpful, but at the end of it all I crept humbled into the laboratory next door. ' I feel an awful bonehead,' I confessed to his neighbour ; ' Dr. X. has been explaining to me for three hours, and I still have not the foggiest idea as to what he is doing.' ' Cheer up,' said his neighbour ; ' I've been working next to him for three years, and I haven't either.'

That may have been an exaggeration, but there was a measure of truth in it. With the intensive specialisation of science, scientists are liable to become unintelligible even to each other. Each branch of science has its own language, but within each branch there are innumerable dialects. The job of the scientific journalist is to reduce it to a kind of Basic English, and I have found a sneaking gratitude for it even among the scientists who profess to despise popularisation.

But scientists, even when they are reconciled to simplification and safeguarded against inaccuracies and misrepresentation, are uneasy about journalistic presentation—headlines, illustrations and tricks in writing. A famous scientist who had collaborated with me in an article which I sent to him for checking returned it with the remark that the facts were all right, but he did not like the style in which it was written. I pointed out to him that I had written it so that it would hold the interest of a Durham miner standing at the pit-head on a wet morning reading about science while he was waiting for the cage to go down. And I do not mean by that ' writing down to the reader ' on the assumption that he is a half-wit who will swallow science only if he is hocussed into it by patent-medicine devices. The British ' average reader ' has a much higher intelligence level than was credited to him by circulation managers. Whenever I was launching a new series of articles, I used to try it out in advance. I used to go round boys' clubs, miners' institutes, women's guilds, and even public-houses and talk over the subjects. I would deliberately fire over their heads at first to see what liberties I could take, and then gradually bring the subject down to commonplace terms. By the time I had finished my sampling, I had a pretty shrewd idea of the type of thing which would interest my readers, and how much they could grasp. There is a disposition both among scientists and newspaper proprietors to confuse poor education with poor intelligence. Some of the most intelligent questions which I have had on modern science came from a group of old-age pensioners at a workers' summer school. None of them had had any schooling beyond the age of twelve.

But our ideas about the average reader, the popular press, and the scientists themselves will have to be radically changed in the light of what

has happened since September 1939. When the British Association met at Dundee in that month it had on the agenda for the Council the discussion of a scheme to establish in this country an organisation for the proper dissemination of knowledge about scientific developments. It was an ambitious scheme which was to be linked with similar agencies in Europe and America. It would have ensured a regular, accurate and up-to-date service for the press, films and radio. That item was never reached ; the news came through on September 1 that the schools of Dundee had to be evacuated. The meeting was abandoned, and I recalled then the fate of the scheme of Jan Comenius, the Czech, who came to Britain in the seventeenth century with a proposal for the establishment of an international centre where the wise men of the world would gather and discuss the practical effects of the impact of the natural sciences on the social organism. A bill to promote his *Pansophica* was before Parliament when the Civil War broke out. It was swept away in the maelstrom. History seemed to be repeating itself in September 1939.

To-day, in the fourth year of war, I have recovered my optimism. I believe that what we projected then—and a great deal more—can be achieved. Drastic things have happened to the average reader, the average journalist and the average scientist since then. The newspapers themselves have been purged ; they have undergone a slimming cure ; and they are the healthier for it. They are in battle-dress. The extravagances and banalities have disappeared. Inflated circulations in the days of paper shortage are an embarrassment. There is no need now for insurance schemes and free gifts to recruit regular readers. To become a subscriber to some newspapers to-day is like trying to join an exclusive club : you have to go on a waiting list and wait for the older readers to die so that you can inherit their copy. Advertising is drastically rationed. Advertisers, having nothing to sell during the war, are producing prestige advertisements to show how public-spirited they are going to be after the war. Some of them are even prepared to devote expensive space to reasonably objective expositions of science. Newspapers, like our diet, have achieved a uniformity, even a certain monotony. Journalism has been dehydrated.

Scientists have also been changed by the war. They have been dragged out of their hermit cells and ivory towers and paraded, as it were, in the barrack square. Their contributions to the winning of the war are not confined to their researches. We have witnessed the greatest laboratory experiment in history in the shape of scientific food rationing. For a generation, scientists have been urging a balanced diet and the proper application of the science of nutrition. Under the imperatives of war we have had it. Instead of experimental rats, we have been practising science on 45,000,000 people. It can be categorically claimed that as a nation we are better fed and healthier than we have been, I suggest, since the beginning of the Industrial Revolution. The health-budget in this the fourth year of war is exceptionally good, in spite of the strains of the intensive war effort in which the workers are producing more per head than the workers of any other nation. The Ministry of Food has done a praiseworthy job in making the people of this country aware of the science of nutrition ; it has done an excellent job in promoting the advancement of science. But scientists have groped their way into the high places of government. They sit at the elbows of statesmen. They have squeezed past the sentries into the Admiralty, the War Office and the Air Ministry. They have got mixed up in strategy ; they have helped to direct military operations. They have got down to the practical problems of industry. The missionaries of science are everywhere proselytising and completing their own education. As one eminent Fellow of the Royal Society said to me recently, ' Now I know what your job is like. I have just been trying to explain a scientific theory to a group of generals. I found myself describing it in terms of Rugby football.'

As for the ' average reader,' a great deal has happened to him, too. Indeed there is a rival British Association for the Advancement of Science ; it has a membership of 25,000,000 ; it is called ' national service.' National service has, one way or another, uprooted those 25,000,000, upset their way of life, put them into the uniform of the services, taken them from offices and drapery counters and put them down at benches, manipulating delicate processes, and given them a new way of life and a new outlook. In a war of scientific weapons they have become to a greater or lesser degree scientific. The humblest civil defence worker has been given some grasp of chemistry ; I have been given tutorial lectures on the character of poison gases, the theory of blast and the trajectory of bombs by an East End docker. I met a barrister the other day who had got 100 per cent. marks in the Signal Corps advanced radio exams., although before the war his knowledge of radio was limited to finding the wavelength of London Regional. A Home Guard the other night first gave me the ' Halt ' and then lectured on astronomy. Girls from sweet-shops are doing higher mathematics on gun sites. Multiply these instances throughout all the branches of the war effort, and you can calculate the millions who know at least enough about science not to be intimidated by the word and to be receptive to its wider implications.

If the newspapers know their job after this war, they will cater for these new interests. After all, the popular newspaper was invented by the late Lord Northcliffe nearly fifty years ago to capture the first literates produced by the Education Act. He catered for their curiosity ; he tried to do through the printed word what the Brains Trust tries to do for millions of listeners every week. That radio feature is called ' Any Questions ? ', but Northcliffe was one up on them even in those days : he called his first weekly journal *Answers*.

Even though most of us here are critical of our education system, I think we would all admit that the standard has advanced considerably since then. Apart altogether from the work in our schools and in the adult education movement, the twentieth century has itself been an education ; the enormous scientific and technical advances have impacted themselves on the most reluctant minds. The people have acquired an interest in science and technology through the very nature

of their jobs and through their hobbies. The war has accelerated and intensified this process of education. We shall have at the end of it all a population which will be alive and receptive to the implications and the applications of science.

This new awareness will have to be satisfied. If the newspapers do not meet this inherent demand, other media certainly will. In the days immediately before the war we saw the growth of the news letter and the digest, which found a public which was not being satisfied by the daily press. We have seen, in war, the growth of the documentary film, and we have seen new interests develop in the radio public. A member of the Brains Trust once remarked to me that the documentary film was 75 per cent. entertainment value. That perhaps was an exaggeration, but if the remaining 25 per cent. had a genuine instructive value, that would be an important contribution to the thinking of this country.

Both scientists and journalists, then, have to face this challenge. How are they going to purvey science in a form which will satisfy the new interest in science which has been created by war conditions? How are they going to be instructional without being dull; to be accurate without being pedantic, and to convert this interest in science into a genuine social instrument? I believe that the British Association, in those discussions which were abruptly curtailed by the outbreak of war, was on the right lines. There is a need for what was provisionally called an Institute of Scientific Information. This British institute would be linked with similar organisations throughout the world, maintaining as between these organisations a regular supply of scientific information for dissemination in the various countries. This institute would work closely in conjunction with the news agencies and newspapers of this country, with the film organisations and with the radio; it would have a staff that would be competent to produce material suitable not only for scientific journalists, but, by a process of treatment, for the unspecialised layman, in the shape of the popular newspaper leader. It would have a panel of expert advisers in all branches of science. The staff would require to be very carefully selected. Ideally its group of writers, in addition to their journalistic qualifications, should, through their scientific interests, cover the whole field of the natural sciences, i.e. the writer with the bias towards, or training in, physics should combine knowledge of engineering, radio, etc.; the biologist might combine anthropology, ecology, etc.; the chemist, biochemistry, industrial chemistry, chemo-therapy, metallurgy, etc.; and the fourth might be concerned with geology, palæontology, archæology, and so on through the various branches.

From a journalistic standpoint, it must be stressed that, in the collection and presentation of news, the scientific expert becomes dangerous if he relies upon his own scientific knowledge, and pontificates. It is fatal for the writer to reject a possible item of news because of his own preconceived views, because, when scientific development moves quickly, past experience or existing ideas become rapidly effete. And, in every instance, an item, when it is collected, checked and written, should be referred back to an expert for cross-checking before release. This does not entail any serious delay in these days of telephones, and, while in the experience of newspapers to-day it is not always possible to do this because scientists naturally object to being imposed upon, the roster of experts would make this easy.

The success of such an institute would depend on the mutual respect and understanding it established between science and the press, as well as with the films and radio. I have always been a strong advocate of this idea, because I believe that science must accept its full responsibility to the community; that it is not sufficient for it to give birth to discoveries and leave them like foundlings on the doorstep of society, disowning all further concern. The scientist is a functional citizen; the scientist—since science must be international in order to fulfil itself—is an international citizen. This is a war for better government, and that better government will depend upon the individual citizen being properly instructed. He must be made alive to the vast potential of the twentieth century and to the vast complexities which science and technology have introduced into the life of society. The scientist has his contribution to make, not only in the shape of his new discoveries, but in impressing upon the public the implications of these new discoveries.

J. G. Crowther

The Publicisation of Science

THERE have been many conferences with the aim of communicating the results of scientific research to the public. The British Association itself has notably pursued this aim through its annual meetings for more than a century. The scope of such work has, however, enormously expanded since the Association was founded in 1831. The volume of scientific work is very much greater, and it is integrated into the intellectual and social life of the community in a much more complicated way.

A hundred years ago, it was desirable that the people should know about science: to-day it is a necessity for survival. Consequently, we can no longer leave the explanation and appreciation of science to occasional and amateur activity. It is a task that must become systematic and professional, if we are to look forward to a scientific civilisation supported by democratic approval, understanding, and participation.

The time has therefore come to examine all the methods which can be used to increase the public understanding and appreciation of science, what may be called the publicisation of science, and see what can be done to improve them.

This conference on Science and the Citizen is the first to be devoted entirely to the consideration of the means for publicising science. In previous conferences we have been concerned primarily with the communication of results: now, for the first time, we have devoted a whole conference to the consideration of the technique by which the public may be helped to understand science.

What is the use of advancing science if the technique of explanation is so undeveloped that we cannot explain the significance of scientific activities? The matter is of personal importance to scientists, because they cannot expect support

and the provision of opportunities unless the significance of their work is understood. But it is of much greater importance in connection with the survival of democratic society and modern civilisation.

There will not be a full appreciation of science and scientific method in governing circles until the people expect that there should be. Attempts to secure notice for science by individual wangling at the top produce an unstable result. A controlling ingredient of popular support is essential for permanence. Science will not be able to take its full part in modern government until it has become the basis of modern culture. One can see what great developments in communication will be necessary before that change has been consummated.

The oldest method of explaining science is by verbal lecturing. Its relative importance in recent years has declined, but it might very well be revived. Young scientists should be encouraged to talk at seminars and meetings. The English have rather neglected the technique of speaking and discussion. Physicists will remember the stimulation which has been provided by the Kapitza Club in Cambridge. When Kapitza started this club, he found that most young English scientists were too shy to join in the discussions. He broke these inhibitions down by making amusing scientific comments that were obviously wrong, and thus providing easy opportunities for joining in with corrections. Thus English scientists were able to benefit from the more flexible Russian conversational traditions. Faraday left interesting observations on the best methods of lecturing, and he took lessons in elocution. Systematic attention to the technique of lecturing would be a useful contribution. In universities and schools, lectures and talks by students should be part of every science course, so that all students of science have had some experience in the technique of exposition. Nor should this technique be allowed to decline in industrial laboratories. Industrial scientists should be encouraged to discuss their researches among themselves, and explain what they are doing to the workers who make use of their results. Industrial scientists should be sent in their working time to take part in the discussions of scientific societies. The Association of Scientific Workers is providing new opportunities to young scientists to learn the technique of expression.

The late Lord Rutherford was fond of recounting how one day, when he was presiding at a meeting of the Royal Society, he had to listen to a rambling exposition by a young biologist. When he had finished, Rutherford said : ' Mr. So-and-so, I am supposed to be a normally intelligent man, but I have listened to you for three-quarters of an hour, and confess I haven't any idea of what you have been talking about. Now will you please tell me in five minutes why you did this experiment, what you were trying to prove, and what result you got.' The young man jumped up and rattled the answers off in no time. ' Thank you, Mr. So-and-so,' said Rutherford, ' that is just what I wanted to know.' If Rutherford were left puzzled, how could a wider public hope to gain any inkling of what was meant ?

The next method of publicisation to be considered is by books. The English have a high standard in science books for the general reader. Faraday and Maxwell, T. H. Huxley and Julian Huxley, Bragg and Eddington, J. B. S. Haldane and H. G. Wells have provided splendid examples. But these have been individual efforts. We might follow the Soviet example of creating teams of writers, trained in the methods of these masters, to explain every aspect of science systematically to the masses.

The radio and the cinema constitute two new methods of publicisation, which have their own technical problems. A great deal remains to be discovered as to how these may best be used.

The only way in which techniques of communication can be efficiently improved is by research, which costs money. Able men should be paid to discover how lecturing can be improved, how scientists should be trained for the microphone and the cinema, and how the output of explanatory books can be increased in number and scope. These tasks should not be left to the casual observations of busy men who are primarily engaged on other jobs.

In addition to these media of publicisation, there is also the press, which has been so widely discussed in this session. The situation, with regard to the press, is pathetic, if not disgraceful. Science is now the chief feature of contemporary culture, yet not one newspaper in this country has a full-time science editor or correspondent. When the war began, science was one of the first topics to be dropped or reduced, though we are engaged in a scientific war. A tremendous opportunity is being missed. Hundreds of thousands, if not millions of people, are engaged in much more scientific and technical operations than ever before. What has been done to extend their scientific understanding on the basis of their new interests ? One might have expected that the newspapers would have carried at least a column a day of scientific and technical copy to appeal to the new technicians. It seems to me that the Minister of Production should take the lead here. He should secure space in the press, like the Ministers of Food and Fuel, and run series of scientific and technical articles on the innumerable fascinating non-secret processes used in the prodigiously wide field of production. I believe he could stimulate the workers' efforts by appealing to their interest in what they are doing. I have no doubt that the total production of the nation could be raised by such means, which of course could be reinforced by more factory technical newspapers, films and radio broadcasts. Many of the big industrial and commercial organisations have already begun to publish scientific articles as advertisements. These activities of the Government and of private enterprise are the first expressions of a tendency which is necessary, and will grow. They are helping to strengthen the public interest in science, and hence create the demand for science news.

As the influence of science increases, and the events of peace and war become even more dependent on it, the social relations of science attract more and more consideration. The proper place for comment on these is in the

editorial columns. In the future, newspapers will devote much more editorial space to science. At present there is only one newspaper in the English-speaking world which has frequent editorials on science. This is the *New York Times*.

The improvement of science reporting in the press depends on the simultaneous advance of several influences. These include the increasing interest and demand from the public, the effects of a higher standard of science teaching, the raising of the school-leaving age, the recognition by owners and editors of newspapers of the growing importance of science, recognition by the State and philanthropic bodies of the necessity for better public understanding of science, the efforts of scientists themselves to make their activities better known and understood, and the promotion of scientific interest which arises from the increasing mechanisation of daily life. All of these influences interact among themselves, and it would be a mistake to ascribe improvement entirely to any one of them. However, the development of science reporting is most easily measured by the amount of money devoted to it. Until it is possible to make a reasonable income from science reporting, very few good men will become what the Americans call science writers. The best solution is for every newspaper to have its own full-time science editor or correspondent. In addition to that, there should be a science news service, providing reliable science news to all newspapers which subscribe to the service. This could best be started by joint endowment by philanthropic bodies and newspaper proprietors.

Very great aid to such a service could easily be provided by the State. In fact, the State has already made a beginning in this direction, through the activities of the British Council, which already conducts a medical information service and a monthly science news letter. At present, owing to the odd way in which the English proceed, these services are available to everyone except Englishmen. This is because of the Treasury principle that if money is allocated for the benefit of people overseas, only people overseas shall benefit from it. An apparatus for publicising science is being built up by the British Council, and there seems no reason why it should not ultimately be accessible to the English. But this cannot happen until the Council receives extra funds allocated for the purpose.

Another direction in which great development is possible is in connection with the Government research departments. A vast and increasing stream of science news comes to them from their own and other laboratories. There is great scope for science writers attached to the staff of the Privy Council, who could explain in simple language the aims, organisation, and results of its scientific activities. It is possible that the many Ministries with science departments would like to have, in addition to their own science writers, a central office where science news could be pooled. The Royal Society and other notable scientific bodies ought also to have their own science writers. Their proceedings and activities would receive much more satisfactory notice, according to their importance, if this were done. The Association of Scientific Workers has already started its own schemes in collaboration with the press. It is certain that this will be fruitful, because many of the younger scientists will grow up press-minded.

There is no simple way of improving science reporting. It can be done only by advancing simultaneously all along the front, with adequate expenditure, effort, and planning.

This session also included a communication by **Prof. J. B. S. Haldane.**

In the course of discussion at the close of the session, **Mr. H. G. Wells** foresaw the decline of the importance of the press as a medium for disseminating news, as against radio and perhaps the telephone. He commended, again as against the press and also against books of doubtful value and appearance, the growing use of pamphlets at the present time, and stressed the public interest in informative material providing for discussion; he also (in opposition to a view put forward in discussion after the first session) recorded his belief that a growing number of scientific men are becoming ' public-minded.'

MESSAGES TO THE CONFERENCE

THE message to the Conference on Science and the Citizen from the Rt. Hon. Sir John Anderson, P.C., M.P., Lord President of the Council, was twice communicated to the Conference and is printed at the beginning of this report. Two other messages, one cabled by Dr. Harlow Shapley and Watson Davies, of Science Service, U.S.A., and the other forwarded by Academician Joffe, Vice-President of the Academy of Sciences of the U.S.S.R., were received too late for communication to the Conference owing to delays in transmission, but are printed below.

Dr. Harlow Shapley, Mr. Watson Davies, Science Service, New York

SCIENCE Service greets British Association's Science and Citizen Conference with fervent hopes that an informed public will appreciate essentiality of science in war, and potentiality of science in post-war reconstruction. Our international ideal is free interchange of the products of the questioning human mind, so that humanity may evolve without destructive strife, but with continuously unsatisfied creativeness. Practically, we suggest immediate international co-operation in distribution and popularisation of scientific information.

Academician Joffe, Academy of Sciences, U.S.S.R.

DEAR FRIENDS AND COLLEAGUES,—I deeply regret being unable to avail myself of the kind invitation

from your President and the British Council, conveyed to me by the British Ambassador, Sir Archibald Kerr.

The reason preventing me from travelling to London is excellently expressed in the very subject of your Conference: Science and the Citizen, which does not admit of my leaving my post and my work just now.

The fate of our and your people, the destinies of free science and culture, are menaced by the peril of which we are fully aware. Hitlerism has studiously fostered all the worst instincts of bestial barbarity which still survived in the German nation, mobilising all the technique of its plants and factories in order to halt progress and culture, in order to annihilate the freedom-loving peoples.

The onslaught which our people is to-day staving off with such unsurpassed heroism will to-morrow with redoubled force threaten you too unless we together destroy the enemy. Events unfold themselves so swiftly that to-morrow will already be too late to put right that which has not been done to-day, without involving huge unnecessary sacrifices.

The duty of every citizen and above all of every scientist able to analyse the dynamics of war is immediately, without delaying for a single day, to apply all his strength and knowledge to the smashing and liquidating of Nazism. We are doing this to the best of our ability, and we believe that our British colleagues, just as we Soviet scientists do, fully understand their duty.

As regards the subject of your Conference, I am sure there is nothing I could say which would not be your own conviction too.

The great pathos of the war for the freedom of my country and of all mankind has aroused in all of us a feeling of responsibility to our people. We know that science is no longer a plaything in our hands but a mighty weapon which, in these stern times, must serve the cause of defending humanity, ensuring mankind a happier future. And these are the tasks of science in days of peace also. The destinies of mankind are not determined by wars alone, as the Nazis preach; they are moulded by centuries of creative toil. In peace and in war time our object is one—the happiness of our peoples, a happy life for all mankind. Science has already accomplished much towards this: people hear each other and will soon see much of each other across the seas and oceans; in cinemas they are witnesses of the great battles of Stalingrad and Moscow and in Libya; within a few hours they are conveyed from one end of the country to the other; they build ships in one month; they raise fruit and vegetables in the winter; they overcome pneumonia and contagious diseases. But at the same time we scientists know better than anyone else what vast opportunities still lie dormant, how long is the path from scientific discovery to its ultimate realisation.

What is needed is to shorten this process so that every citizen himself feels the full benefit of science and research.

We have long ago in this country set ourselves this task. Our people, our Government have demanded its solution of us. With this aim in view we carefully thought out plans for our work, concentrating our forces on the most vital problems and seeking the most effective means to introduce into practical life what we have mastered. We do everything possible so that our knowledge speedily becomes the domain of engineers, physicians and agronomists who can give it practical application; the domain of the workers who effect those physical and chemical processes which we investigate. Finally it is necessary that this knowledge forms part of the foundation of general education in the schools and among the general population.

We organise joint work between scientists and engineers. Even without planning, science brings benefit, but its rôle vastly increases when this aim is consciously striven for.

Allow me to disperse some regrettable misunderstandings. The introduction of planned principles in science by no means signifies narrow practicism, rejection of fundamental theoretical researches which give no immediate practical results. On the contrary, a proper plan demands that, side by side with the utilisation of science for current tasks, it also lays the foundation for the future. History teaches and our experience proves outright that major practical results are achieved when succeeding in revealing the mechanism of natural phenomena, when attaining the broadest possible generalisations.

Theory and practice mutually support each other. There is no better checking of theory and analysis of its shortcomings than the experience of mass production. Allow me to cite an instance of my own experience: solely by means of developing Quantum Theory semi-conductors we have succeeded in raising dozens of times over the current given by new rectifiers, photo-elements and thermo-elements. On the other hand, many features of this theory were prompted by failures in factory production.

Another misunderstanding which has not yet been fully dispersed is the conviction that the sole aim for scientific creation should be the striving for knowledge and not its benefit for mankind.

When you learn that so and so many ships with thousands of sailors have been saved, that so and so many air-raids threatening our native towns have been averted, that so and so many tanks have been saved owing to your work; if you are given grounds to think that the scientific activity of yourself and your comrades in the Academy of Sciences helps to avert the menace threatening to enslave your people—does not this multiply our strength and promote the success of our research?

We scientists enjoy the privilege of combining two supremely gratifying features; in striving for knowledge we thereby increase the happiness of our people and win its recognition. Both these aspects stimulate the development of science and make the scientist a worthy citizen, as distinct from the bridge player who enthusiastically spends nights at his card hobby but without any benefit for mankind.

Modern science is proceeding by the united efforts of many scientists who all tackle one problem from various angles. Individual attempts seldom yield important results. Therefore a man of learning who is isolated from life is not only a bad citizen but also a poor scientist.

I feel that I am not telling you anything new; the reason I am telling you these truisms is that for us they are the result of the experience of twenty-five years on which our science has grown up and which is so highly appreciated by our people. From the first day of war we scientists joined the people's ranks and took our stand in the defence of our country. From us scientists each soldier and sailor expects help, and we do not disappoint them. As they at the front, so we in the laboratory, dedicate day and night to our single cause. This is the cause of all scientists, all citizens who love their freedom and respect the freedom of other nations.

Stimulated by patriotic feelings, science constitutes a pre-potent force; and this force is in our hands.

On the side of freedom is the overwhelming military and economic might of our Soviet Union and Great Britain and the U.S.A. We have the sympathy of all enemy-seized countries. These forces are more than ample fully to exterminate the Brown Plague if only they are brought into full action. The sooner this is done, the surer is victory, the less the sacrifices being borne by the whole world. Before us stretch bright perspectives of progress and free development of all peoples along the roads they themselves may choose. Before us stretch the boundless perspectives of scientific creative endeavour.

Let us then unite our efforts quicker to disperse this menace so that the free citizen can breathe deep again. Time does not wait: the sufferings of millions grow.

Dr. Chuchia-Hua, President of the Chinese Academy, Chungking

We confidently hope your Conference will succeed in making importance of science understood by every citizen and in making its benefits accessible to all.[1]

MINERAL RESOURCES AND THE ATLANTIC CHARTER

The control and use of mineral resources after the war formed one of the questions raised at the Conference on Science and World Order, held in September 1941 by the Association's Division for the Social and International Relations of Science. The transactions of this conference were published in *The Advancement of Science*, No. 5, January 1942. The Division subsequently arranged a conference on Mineral Resources and the Atlantic Charter, which was held in July 1942, and is fully reported in *The Advancement of Science*, No. 7. From that conference a recommendation was forwarded to the Council of the Association, to the effect that the Council should initiate consultations with appropriate scientific and technical organisations, to secure an understanding on the principles involved; that a scientific review of mineral resources should be among the first tasks of any international organisation for the social applications of science, and that to this end the Council should consider how it might help to promote the establishment of an International Resources Organisation as a fact-finding and advisory body for Governments, as a contribution to world stability, and in the spirit of the Atlantic Charter.

The Council thereupon appointed a committee, whose terms of reference and report follow below. It consists of Sir Thomas Holland, K.C.S.I., K.C.I.E., F.R.S. (Chairman); Dr. C. H. Desch, F.R.S. (Vice-Chairman); Dr. David Williams (Secretary); Sir Richard Gregory, Bt., F.R.S. (President of the Association); Prof. F. T. Brooks, F.R.S., and Prof. Allan Ferguson (General Secretaries of the Association); Dr. E. F. Armstrong, F.R.S., Prof. J. D. Bernal, F.R.S., Prof. P. G. H. Boswell, F.R.S., Mr. Ritchie Calder, Dr. William Cullen, Sir Lewis Fermor, O.B.E., F.R.S., Sir Harold Hartley, F.R.S., Mr. J. Allen Howe, O.B.E., Mr. S. J. Johnstone, O.B.E., Prof. W. R. Jones, Sir William Larke, K.B.E., Sir Harry Lindsay, K.C.I.E., C.B.E., Mr. A. Notman, The Hon. R. M. Preston, D.S.O.

REPORT OF THE MINERAL RESOURCES COMMITTEE

The Committee's terms of reference are 'to inquire into, and report upon, the state of knowledge of mineral and metal resources, other than coal and petroleum, essential for modern industrial development from the point of view of the Fourth Clause of the Atlantic Charter.'

The Fourth Clause promises to all States, great or small, victor or vanquished, access on equal terms to the raw materials necessary for their economic prosperity. Obviously this promise can be implemented only by a specially constituted body, established as an international authority and supplied with information sufficient to estimate the quantities of mineral materials which each country may be expected to import to meet its growing economic needs, without accumulating additional stocks designed to serve possible aggressive ambitions of a military kind.

For an international organisation to act effectively, it will require reliable information regarding the mineral resources of each national unit, and its stock of information will need constant repair with the progress of geological surveys and the development of mineral industries. Our problem as a Committee is to suggest methods for obtaining and keeping up to date the essential facts.

Recent history of the mineral industries justifies

[1] Received through Dr. Joseph Needham and the British Council.

a recognition of a few general conclusions which must be taken into account in solving the problems that the projected international authority will have to face. These are :—

(*a*) Countries vary greatly in their mineral self-sufficiency, no one among them being quite self-contained ;

(*b*) Although some essential chemical compounds which occur as natural minerals can be made artificially, they can be made only from other mineral sources. For example, cryolite, which is necessary as a flux in the electro-smelting of aluminium, and occurs naturally only in Greenland, can be made by combining the fluorides of aluminium and sodium, but the fluorine must still be obtained from the mineral fluor spar, which is not obtainable in all countries in commercial quantities.

(*c*) During the few years before the present war the consumption of minerals increased, both in kind and quantity, at an accelerated rate, and will certainly continue to increase still more with the development of technical industries after the war ;

(*d*) The recovery of scrap metal, which has rapidly developed, may retard the rate of acceleration, but almost certainly will not prevent an increase in the world's consumption of raw mineral products ;

(*e*) Some mineral raw materials, for example, ores of aluminium, antimony, manganese, tin and tungsten, which are essential for the development of technical industries, occur, according to our present knowledge, in workable quantities and richness of grade mainly in the less industrialised areas, and are relatively unobtainable in countries where they are in great and increasing demand. Consequently, prohibitive laws to prevent their exploitation or unreasonably high export tariffs must necessarily retard industrial development in areas which are deficient in certain of those key metals ;

(*f*) It may become desirable, however, in each country where the raw materials are exploited by mining operations, to carry on processes of smelting and refining to the highest stage possible preparatory to export of the final products to consuming countries. In addition to economy in transport costs, it will be for the general good of the so-called backward areas to encourage the development of the accompanying technical industries and education *in situ.*

Sources of Information

Our present ideas concerning the distribution of mineral resources which are workable on commercial lines are based on two main sources of information :

(*a*) Published reports of mining companies, and of geological surveys, which are systematically conducted by official organisations in the most advanced countries. Conclusions drawn from such reports, both official and private, are generally of qualitative value only ; and,

(*b*) Published statistics of annual production, exports and imports, which give, with some qualifications, a rough indication of the capacity of each country and of its requirements to meet normal current, peace-time technical industries.

(a) *Geographical Distribution of Mineral Deposits*

The location of mineral deposits is controlled by geological factors and has no direct relation to national boundaries. The broad geological features of the world are probably sufficiently understood to permit some generalisations concerning the extent of areas known to be mineralised and favourable to the existence of particular types of mineral deposits. Magmatic-ore deposits, for instance, are closely connected with tectonic folding movements and associated igneous activity, and as a consequence are often spatially related to mountain systems which have been more or less deeply eroded by weathering agents, as in the Andes, Urals, Caucasus, and Malaya. The conditions under which economic deposits of sedimentary origin, such as rock salt, gypsum, phosphorite, potash, and deposits of residual bauxite, accumulate, are also generally appreciated, and the regions where they may occur can be roughly inferred and delineated. Just as certain areas can be declared favourable, on geological evidence, to the occurrence of particular kinds of mineral deposits, so other regions are known to be devoid of specific minerals. For example, tin and tungsten are always found in areas containing granitic rocks and never occur in direct association with ultrabasic igneous rocks, whereas the reverse is almost invariably true of primary chromite and platinum deposits ; moreover, those regions composed of Archean rocks can be ruled out immediately when searching for commercial sources of coal, petroleum, or other deposits of organic origin.

Although many large areas of the world, such as the greater part of North America and Europe, have been geologically surveyed in considerable detail, even in these regions improved methods of exploration and prospecting will lead to the discovery of additional mineral deposits. On the other hand, there are immense areas which have so far received only the most cursory investigation, the outstanding examples being China, Brazil, and parts of Soviet Asia. Smaller areas, such as the Balkans, Indo-China, and portions of Central Africa, are also incompletely explored from the mineral standpoint, although likely to contain many valuable deposits.

Where the solid rocks are mantled by drift and superficial deposits, the co-operation of geologists and geophysicists may reveal the presence of hitherto unsuspected mineral deposits or prove the extension of known orebodies.

(b) *Production and Trade Figures*

Among the voluminous literature dealing with statistics concerned with mineral production, imports and exports in various countries, the most valuable summaries are those issued annually by the Imperial Institute, in the Minerals Yearbook of the United States, and in other Government publications. Details of other statistical publications are appended to the annual summaries published by the Imperial Institute and need not be referred to here.

Although these statistics afford a rough guide to the distribution and magnitude of mineral deposits now actually being exploited, they obviously cannot indicate the extent, nature, and

exact geographical distribution of the world's resources. Owing to national policies aimed at stimulating domestic production, artificial barriers to international trade, import quotas and tariffs, bargaining measures and the like, the output figures of a country are not necessarily a reliable index to its mineral reserves of economic value or a sure clue to its productive capacity. Moreover, the import and export data published in the statistical tables, based on customs returns, cannot always be accepted as indicating the countries of origin of particular commodities. The amassing of stocks of strategic mineral raw materials for military purposes in many countries has hitherto tended also to mask the value of such statistics as a reflexion of a country's mineral resources or normal requirements. Some countries import valuable raw materials ' on Government account,' these being deliberately omitted from published trade statistics.

Partly because recent developments have been so rapid, many countries have not hitherto circulated production figures relating to several essential minerals, and the reliability of recent mineral trade statistics in some countries has not always been above suspicion.

Even the most intelligent assessment of production, import and export figures can therefore give only a crude indication of the real extent and provenance of the world's potential mineral supplies.

Estimates of Mineral Reserves

The estimation of mineral reserves, even when actuated by the best motives, under favourable circumstances, is notoriously difficult. Mining has always been a more or less hazardous adventure and the very nature of ore deposits usually makes estimates of their reserves difficult, and valid only for limited periods beyond actual exploitation. It is true that in the more industrially developed parts of the world and where large-scale mining is being conducted by modern methods, a shrewd estimate of the ore reserves within particular mining fields is often available. Thus, for instance, there is adequate published information concerning the nickel reserves of Ontario, the pyrite deposits of Spain, the copper resources of Northern Rhodesia, North America, Chile, etc., and the lead-zinc orebodies of Missouri. On the other hand, where mining is still being pursued by primitive methods, as in parts of China and South America, there is little specific information concerning the amount and grade of ore reserves. Comparatively little is known, for example, regarding the tin reserves of the Far East and Bolivia, or the antimony resources of China.

When quantitative data are given concerning mineral resources, it is usual to employ the phrase ' mineral reserves ' or ' ore reserves,' rather than ' mineral resources,' though there is really no significant difference between the two phrases. It is necessary, however, to mention two uses of the phrase ' mineral reserves.' When a mining company speaks of the reserves of ore in its concession or mine, the reference is usually to the quantities of economically-extractable ore proved or partly proved by survey and development, and does not include the additional amount of mineral that may be in the ground, but which has not yet been proved. To the nation, however, both these quantities of ore, known and unknown, must be regarded as part of the mineral reserves or resources of the country. Thus, whilst the total of the known reserves of any mineral is constantly changing with the course of discovery, development, and exploitation, and with improvements in technique, so that the rock of lower grade, formerly rejected, comes into the category of valuable mineral or ore, any survey of the mineral resources of a country should aim at including not only the known reserves but also the reserves that may exist, but have not yet been brought under estimation. And any policy bearing on the mineral resources of a country should not neglect these undiscovered and unproved reserves.

When estimates of quantities of ore are given, these quantities should be classified according to the degree of certainty of knowledge, e.g. proved, partially proved, and unproved ore. So far as possible, the grade and quality of the ore should also be specified, since such data frequently determine the suitability of a mineral for particular applications in industry.

National Surveys of Resources

The need for a survey of domestic resources was implemented in the United States in 1934 by the establishment of a National Resources Board which now provides the most complete and comprehensive domestic statistics on resources of any country. A similar review of the mineral resources of the British Commonwealth of Nations is long overdue. Data concerning plant capacity for mineral production and metal smelting are also necessary.

The full re-assessment of world resources obviously cannot be undertaken until after the cessation of the present hostilities, when it is hoped that each country will institute a Resources Board to compile information relating to its own domestic supplies, details of which will be available to an International Organisation. It is appropriate to mention here that under its terms of reference the Mineral Advisory Council of the Imperial Institute advises as to the collection, co-ordination, and dissemination of information relating to mineral resources in the British Empire, and it does actually function to a limited extent as a Mineral Resources Board. Unfortunately, the Mineral Resources Department of the Imperial Institute is inadequately staffed and financed to achieve its full purpose.

In the appendix to this Report, a selected list of references dealing with the mineral and metal industries is given. Of particular interest is the survey on *The Mineral Reserves of the United States and its Capacity for Production*, compiled by K. Leith and D. M. Liddell in 1936 for the Planning Committee for Mineral Policy in the U.S.A. This publication is an example of the type of information on mineral resources which should be compiled for each country or national unit.

Despite the long list of available references, our knowledge of the world's mineral resources is far from complete, though with regard to many mineral raw materials the information is probably

adequate for the purposes of guiding an immediate post-war policy.

A mass of data relating to ore reserves and potential supplies is hidden away in the confidential records of mining companies and mining engineers. In various parts of the world there are extensive mineral deposits which have remained undeveloped owing to political or commercial considerations. During recent years intensive prospecting, especially in the U.S.S.R., has disclosed many new deposits, details of which have not yet been published. Until an authoritative international commission for the collection and correlation of information is established it is unlikely that much of this information will be divulged.

Scrap Metal Supplies

The total of the mineral resources of the world is an unknown but practically fixed quantity that is being reduced continuously year by year, to a minor extent by the processes of geological or natural denudation, and to a major extent by human extraction or mining. This continuous and rapid depletion of mineral capital is offset to a growing degree by the recovery and return to industry of appreciable and often important quantities of scrap metal, such as iron, steel, copper, lead, and tin.

The importance of recovering metals from scrap is still far from adequately recognised, although scrap now provides a substantial proportion of the immediate raw materials of the metallurgical industry. There is an urgent need for the institution of measures that will ensure a maximum recovery of scrap, and for the gathering of international statistics relating to the available supplies of scrap metal, according to a universally agreed basis of classification.

An exact study of the fate of industrial metals is impossible owing to the lack of available statistics, and to the uncertainty as to their secondary uses. One of the main difficulties of getting a true statistical picture of scrap recovery is the extent to which certain scrap is re-used directly without coming into the market. Nevertheless, it should be possible to collect data for all scrap which does reach the market, so as to determine to what extent consumption in each country can be met from virgin metal and from scrap.

The absence of world statistics on the recovery of scrap makes it impossible to give a comprehensive picture of its full significance. With the exception of the United States no country compiles figures of secondary metal production, and the subject of scrap remains the great blind spot of the world's metal economy. Clearly the aim should be to collect all possible statistical data concerning scrap metal supplies for correlation with details of world mineral supplies, in order to formulate schemes for the best utilisation of the total mineral and metal resources.

Despite the lack of statistics regarding scrap-metal recovery, one striking example can be given of the importance of scrap metal in the world's economy. A graph of the world's total pig-iron and steel production over some decades shows that until 1914 the world's annual output of steel was less than that of pig-iron, with the curves gradually approaching ; that in 1914 these curves crossed ; and that since that year the world's production of steel has constantly exceeded the amount of pig-iron. This crossing was due to a progressive increase in the proportion of scrap used in place of iron-ore in the open-hearth process.

Prospecting and Mining Concessions

Among the signs of a recrudescence in national exclusiveness which followed the war of 1914-18, new regulations were designed in many countries —some British controlled areas as well as others— to exclude alien venturers from holding unqualified mining rights. These naturally generated friction which resulted occasionally in the institution of retaliatory measures.

The restrictive regulations appeared in varied guises, either applicable to aliens generally or only to ex-enemy aliens, such as enforced employment of native technical labour, allotment of a dominant share of capital to local investors, enforced institution of smelting and refining works within the same or in a politically related country, local registration of the prospecting syndicates or mining companies, with a native majority on boards of directors. Some of these conditions may be harmless or even desirable ; some, through ignorance, may be unnecessarily irritating.

A general international understanding, with a qualified freedom in these matters, will be difficult to re-establish without a much wider realisation of the principles on which the grant of prospecting licences and mining leases should be based. The popular impression that a successful mining company in an industrially backward country takes away its profits as well as depleting the country's natural and irreplaceable resources is the common excuse for the imposition of a restrictive policy. Quite obviously, admittedly and justifiably, mining companies, alien or native, hope to make profits ; otherwise, money would not be invested at all in enterprises of the sort. Those that are definitely successful make 'copy' for local journalists and their leaders become conspicuous as various species of the mining magnate genus. The far more numerous small failures pass unnoticed or are quickly forgotten by the general public.

Prospecting and mining operations, especially for oil and metalliferous ores, always include elements of uncertainty and therefore of speculation, whilst the occasional successes appeal to the endemic love of a gamble, which may be relatively harmless so long as each investor limits his risk to no more than he can afford to lose. Both successes and failures in mining ventures based on foreign capital bring something to the country in which they occur, although neither its Government nor the unlucky venturers advertise the fact. But every well-conducted Government endeavours to limit the failures to justifiable commercial risks by prescribing conditions which are estimated to safeguard its mineral resources whilst attracting well-advised capital for their development ; for it is wiser to work mineral deposits than to leave them lying idle in the

ground and therefore inaccessible in times of emergency. It may be observed here that successive British Governments have failed to prescribe conditions attractive to capital for the development of mineral resources in the United Kingdom, and attention to this matter is long overdue. The acquisition of mineral rights by the State would enable Governments in the future, in Great Britain for example, to take a more active interest in their own mineral resources.

The problem before each Government, or each large owner of mineral rights, is to frame regulations for the grant of mining concessions so as to attract the honest and technically qualified investor, whilst ensuring a fair return to the State. With this object in view well-advised Governments grant concessions roughly in three stages as (1) exploration rights over relatively large areas for very limited periods ; (2) prospecting licences over parts of the explored areas for longer, but still limited periods ; and (3) mining leases within the prospected areas for periods long enough for a well-conducted mining company to recover its capital outlay ; for a worked-out mine is obviously unsaleable. The results obtained in each of these successive stages should justify the further investment of money on the next following stage as a reasonable commercial risk. Experience on many mining fields shows that the terms prescribed range from about one year for geological exploration, two to five years for prospecting, and from at least twenty-one years for a mining lease. The mining lease naturally carries many obligations on the part of both the lessor and lessee which are not prescribed for prospecting and exploring —the lessor demands that operations shall begin within a prescribed period and thenceforth be carried on effectually in a skilful manner ; that the lessee pays a reasonable royalty on the mineral sold, with a minimum annual amount known as a dead rent ; that a rent at local prices is charged for the land occupied ; that accurate plans are kept, that suitable provisions are made for the health and safety of the miners. The lessee expects sufficient water rights, rights of access, and an agreed limit to new rates of royalty and rents among other conditions accompanying his right to claim a renewal of his lease for a further period on the expiry of his first lease.

Such safeguarding conditions on both sides need not be detailed in this Report, but examples of the application of the principles are shown in the mining laws of most industrially developed countries.[1] Our purpose now is to point out the advantages to those countries not yet industrially developed in prescribing reasonable mining laws which are calculated to encourage industrial development without undue speculation or a tendency towards harmful company promotion ; and, above all, regulations which do not savour of national exclusiveness ; for, in spite of a vague impression to the contrary, the investment of foreign capital in mining constitutes a smaller political risk to the State than any of the common conditions under which foreigners carry on business in other civilised States. Even under war conditions an investor of enemy origin cannot take away the mine in which he has invested his money. It must be left behind and to that extent adds to the conditions which tend to restrain the outbreak of hostilities.

[1] For example, in volumes published by the Imperial Institute : *The Mining Laws of the British Empire and of Foreign Countries*, 12 vols., 1920–30 ; *Mining Royalties and Rents in the British Empire*, 1936.

General Conclusions

As no country can, or will ever be able to, provide from its own natural resources the full variety of minerals which are necessary for its economic prosperity, and as some countries possess more than they require of certain minerals, it is essential to remove, in every way that is practicable, any obstacles which may have hitherto prevented the free interchange of such raw materials.

The principal way at present of estimating the resources of each country is based on published figures for its annual production and external trade ; but further information regarding undeveloped resources is obtainable from official surveys and from the records of prospecting and mining companies which can be revealed in general terms without detriment to any company's commercial interests.

Obviously, it is in the general public interests that no country should conceal information regarding its resources in raw materials, or be permitted to accumulate stocks in excess of its economic needs, either of raw materials or of recovered scrap metal.

Although reliable estimates of resources have been made for a few countries only, there is sufficient information already available to permit the framing of a general policy designed to regulate the flow of essential mineral supplies, from countries in which certain of them occur in excess of domestic requirements, to others which are deficient in the natural products required for their essential peace-time industries. The example which has been set by the United States most conspicuously of collecting and publishing full information annually will be followed quickly by other nations, when they find that the help afforded to them by an International Resources Organisation will be proportionate to their own contributions to the central pool of information. As previously suggested, therefore, a Minerals and Metals Resources Board should be established for each convenient national unit, with the object of preparing a detailed and comprehensive survey of its own resources. Such an organisation should preferably be under Government control, working in co-operation with the various geological surveys, mines departments, and bureaux of metal statistics of the constituent governments.

In order to assess the quantity of raw materials necessary for the economic prosperity of a country it will be imperative to have reliable statistics of the quantity and grade of mineral consumed by each of the more important trades in each country using the mineral or metal. So far the only country which, pre-war, published statistics of consumption by trades was the United States, Canada supplying a rather less complete but useful list. It is evident, therefore, that many countries, including the United Kingdom, would have to make arrangements for the collection of such data before any satisfactory picture could be obtained. Statistics of total apparent con-

sumption in a country of a mineral based on the difference between total production plus imports less exports are of little value for the purpose of the Fourth Clause of the Atlantic Charter.

Appendix

Publications Dealing with the Mineral and Metal Industries

(Compiled by the Imperial Institute Mineral Resources Department)

The following selected list may be useful to those who wish to study the various aspects of mineral production, occurrences, resources, technology, utilisation, and strategy.

Statistics of Mineral and Metal Production and Trade

The Mineral Industry of the British Empire and Foreign Countries—Statistical Summary (annual), the Imperial Institute (453 pp.). Gives production and trade statistics and includes a comprehensive list of official publications, both Empire and foreign, which contain mineral and metal statistics.

Statistische Zusammenstellung über Aluminium, Blei, Kupfer, Nickel, Quicksilber, Silber, Zink und Zinn, by the Metallgesellschaft, Frankfurt-am-Main (annual) (125 pp.).

The Mineral Position of the British Empire, the Imperial Institute, 1937 (166 pp.). Summary of occurrences, production and trade.

Empire Mineral Resources and their Relation to the War Effort, by S. J. Johnstone. The Institute of Chemistry, London, 1941 (85 pp.).

Year Book of the American Bureau of Metal Statistics (annual), American Bureau of Metal Statistics, New York (120 pp.).

Quinn's Metal Handbook and Statistics (annual). Prices, exports, imports and production of chief metals. Metal Information Bureau, Ltd., London (343 pp.).

Statistiques—Minerais et Métaux. Copper, lead, zinc, tin, aluminium, gold and silver (annual). Minerais et Métaux, Paris.

Statistical Year Book of the League of Nations (annual). League of Nations, Geneva (330 pp.).

General (Annuals)

The Minerals Yearbook, U.S. Dept. of the Interior, Bureau of Mines, Washington, D.C. (1,459 pp.).

The Mineral Industry, by G. A. Roush. McGraw-Hill Book Co., New York (780 pp.).

The Metal Industry Handbook and Directory, The Louis Cassier Co., London (480 pp.).

Handbooks on Resources of Individual Countries and Minerals

The Coal Resources of the World, 12th International Geological Congress, 1913, 3 vols. (1,266 pp.).

The Gold Resources of the World, 15th International Geological Congress, 1929 (457 pp.).

The Copper Resources of the World, 16th International Geological Congress, 1935, 2 vols. (855 pp.).

The Mineral Reserves of the United States and its Capacity for Production, by K. Leith and D. M. Liddell; for the Planning Committee for Mineral Policy (Washington, U.S.A.), 1936.

The Iron Ore Resources of the World, 11th International Geological Congress, 1910, 2 vols. (lxxix + 1,064 pp.).

Les Réserves Mondiales en Phosphates, 14th International Geological Congress, 1926, 2 vols. (900 pp.).

Les Réserves Mondiales en Pyrites, 14th International Geological Congress, 1927, 2 vols. (703 pp.).

Quinquennial Review of the Mineral Production of India for the years 1929 *to* 1933. Rec. Geol. Surv. India, Vol. LXX, 1936.

Annual Reviews of the Mineral Production of India. Rec. Geol. Surv. India for years 1934 to 1939.

Report upon the Mining Industry in Malaya, by L. L. Fermor. Kuala Lumpur, 1939 (240 pp.).

The Mineral Resources of the Union of South Africa, Dept. of Mines, 1940.

Imperial Institute Monographs on Mineral Resources.—A series of over 50 volumes each dealing with the occurrence, trade, and utilisation of one particular mineral or metal throughout the world. (Each volume includes a selected bibliography.)

Minerals from the Strategic Aspect

Strategic Mineral Supplies, by G. A. Roush. McGraw-Hill Publishing Co., London and New York, 1939 (485 pp.).

Political and Commercial Geology and the World's Mineral Resources, by J. E. Spurr. McGraw-Hill Publishing Co., London and New York, 1920 (562 pp.).

The Strategy of Raw Materials, by B. Emeny. The Macmillan Co., New York, 1934 (202 pp.).

The Mineral Sanction as an Aid to International Security, by Sir Thomas H. Holland. Oliver and Boyd, Edinburgh, 1935 (95 pp.).

Elements of a National Mineral Policy, by the Mineral Inquiry of the American Institute of Mining and Metallurgical Engineers, New York, 1933 (162 pp.).

World Minerals and World Politics, by C. K. Leith. McGraw-Hill Publishing Co., New York, 1931 (213 pp.).

The Nationality of Commercial Control of the World's Minerals, by W. P. Rawles. The Mineral Inquiry, New York, 1933 (44 pp.).

Marketing and Uses of Minerals

(see also Imperial Institute publications under 'Handbooks').

The Marketing of Metals and Minerals, by J. E. Spurr and F. E. Wormser. McGraw-Hill Publishing Co., London and New York, 1925 (674 pp.).

Industrial Minerals and Rocks (non-metallic minerals other than fuels), Seeley W. Mudd series, Amer. Inst. Min. and Met. Engineers, New York, 1937 (955 pp.). Each chapter includes a short bibliography.

Mineral Raw Materials, by the Staff of the Foreign Minerals Division of the U.S. Bureau of Mines. McGraw-Hill Publishing Co., London and New York, 1937 (342 pp.).

Publications dealing with Scrap Metals

(compiled by Sir Harold Hartley).

International Scrap Convention, by J. F. L. Elliott. *Stahl und Eisen*. March 16, 1939, LIX, pp. 330–331.

Corrosion: Its Causes and Prevention, by F. N. Speller. McGraw-Hill Book Co., London. Pp. xlii + 694, 2nd edn., 1935.

Metal Statistics, 1940, 33rd Annual Edition published by the American Metal Market, New York, 1941.

National Resources Board. A Report on National Planning and Public Works in relation to Natural Resources, and including Land Use and Water Resources with findings and recommendations. Part IV. Report of the Planning Committee for Mineral Policy. Pp. 429. Government Printing Office, U.S.A. December 1934.

Scrap in the Export Trade, by J. W. Reichert. *Stahl und Eisen.* March 16, 1939, LIX, pp. 325–330.

Scrap Metals, by G. H. Manlove and C. Vickers. Penton Publishing Co., London. Pp. 275, 2nd edition, 1925.

Secondary Aluminium, by R. J. Anderson. Chapman and Hall, Ltd., London. Pp. xv + 563. 1933.

Secondary Copper, by P. E. Barbour. Mining and Metallurgical Society of America. Pp. iv + 85. 1935.

Statistical Year Book, 1939. International Tin Research and Development Council. London. 1940.

Statistics of the Iron and Steel Industries. British Iron and Steel Federation. London. 1937.

Technological Trends and National Policy, including the Social Implications of New Inventions. Report of the Subcommittee on Technology to the National Resources Committee. Government Printing Office, U.S.A. 1937. Pp. 329.

The Economics of Old Metals, by W. R. Ingalls. *Bulletin of Mining and Metallurgical Society of America*, November 1935, XXVIII, pp. 75–94.

Year Book of the American Bureau of Metal Statistics, 21st Annual Issue, 1940. Published by the Bureau, New York. 1941.

SCIENTIFIC RESEARCH ON HUMAN INSTITUTIONS

A COMMITTEE for the consideration of scientific research on human institutions was formed during 1942 and held its first meeting on August 26. It subsequently met about once a month until June 9, 1943.

The Committee consisted of: Prof. P. Sargant Florence (Chairman); Mr. L. J. F. Brimble (Hon. Secretary); Mr. H. J. Braunholtz; Prof. G. Catlin; Prof. C. H. Desch, F.R.S.; Mr. A. Farquharson; Prof. J. C. Flugel; Prof. Morris Ginsberg; Prof. Lancelot Hogben, F.R.S.; Dr. Julian Huxley, F.R.S.; Prof. Harold Laski; with the President and General Officers of the British Association.

The terms of reference were: To consider how the results of scientific research on human institutions and human needs and their interrelations can best be co-ordinated and brought to bear on the formation of public policy. The report was presented to the Council in June, 1943.

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I

INTRODUCTION

The British Association has thirteen sections—of these six deal with pure natural sciences, two (engineering and agriculture) with applied natural sciences, and five (geography, economics, anthropology, psychology and educational science) partly or wholly with human institutions. One of the main interests of this Committee in co-ordinating the results of scientific research is therefore the relationship and similarity or dissimilarity of methods of research and scope of interest in the natural and the so-called social sciences. The inclusion of human needs in the terms of reference admits the social implication even of the most 'pure' sciences. Knowledge of nutritional needs depends, for example, on progress in chemistry, physiology and possibly zoology. In short, the report of this Committee must begin with a consideration both of the boundary line and of the interrelation between the natural and the social sciences before proceeding to practical recommendations on education in the social sciences and the organisation of those sciences. The conclusions of the Committee at this stage may be summed up in four propositions.

1. The social sciences have specific problems marked off from the natural sciences other than those directly connected with the impact of technology on human institutions. These specific problems require different adaptations of the

scientific technique of measurement and enumeration. The social sciences require, for example, special developments in the theory of the association of attributes rather than that of the correlation of variables.

2. Yet the Committee agree that the impact of technology on human institutions and of medical discovery on social valuations have a peculiar topical importance ; and that natural and social sciences both involve preliminary qualitative specification of the domain of reference with the aim of as much quantitative precision as is practical.

3. There is a need for co-operation therefore in developing border-line enquiries between the social and the natural sciences of special topical relevance ; and need, too, for a broader sort of education for the promotion of knowledge and research directed to that co-operation.

4. For the purpose of co-ordinating scientific research on human institutions and human needs and their interrelations and of bringing them to bear on the formation of public policy, an organisation is required that will embrace all the social sciences, have contact with representatives of the natural sciences, speak authoritatively in advising the government and institutions disbursing funds, and publish information and the results of research. Given these functions, the form the organisation shall take is not difficult to devise.

Section II of this report deals in some detail with the first two of the above propositions ; Section III with the third ; Section IV with the fourth.

II

Scope and Method of Research on Human Institutions and Needs and their Interrelations

In the search for the boundary line which marks off the social sciences from other fields of knowledge it is illuminating to begin by taking note of the scope of the natural sciences as understood by the Royal Society ; for the prestige of the Royal Society is such that its view of the delimitation of the field of the natural sciences may be regarded as an authoritative expression of the opinion of workers in that sphere. The opinion of the Royal Society in this matter may be inferred from a study of admissions to fellowship ; when admission is granted to a worker in a particular line of enquiry, it may be said that the Royal Society has ' recognised ' this line of enquiry as within the natural sciences. The natural sciences fall into two groups, the physical and biological, and it is the Royal Society's view of the extent of the latter which is of special interest in this context. We are led, therefore, to examine the extent to which the ' recognised ' biological sciences deal with man, and we discover that they are confined to the investigation of those attributes of man which are common to other species and can therefore also be investigated in like manner ; thus the palæontological, anatomical, physiological, pathological, genetic, psychological and biochemical aspects of man are studied precisely as in the case of any other species ; the investigation of variation within a species is studied in a similar fashion but has been so extensively developed for man that it is known as physical anthropology.

It emerges that the ' recognised ' biological sciences do not deal with social data, that is with facts arising from the contact of man with man, whether individually or in groups ; the best evidence for this conclusion is that the Royal Society ' recognises ' physical anthropology and experimental psychology, but stops short at social anthropology and social psychology. This is the existing line of demarcation ; it is satisfactory because it is clear. The natural and the social sciences are not distinguished by the use of different methods, but by the subject-matter which they investigate ; for both employ deduction, classification and induction. They are alike in that they take no account of values, but are concerned with the assembly, analysis and classification of data from their chosen fields.

If the Committee is concerned with something more than academic discussion, two matters call for prior consideration, namely :

(*a*) how far workers in the natural and social sciences can co-operate in the conduct of border-line research which impinges upon both types of enquiry ;
(*b*) to what extent common action is desirable to promote more effective research in the latter.

If there is little scope for co-operation of the former type it is difficult to see any compelling reason for enlisting the help of research workers in the natural sciences with a view to common action to encourage research in the social sciences.

It is therefore important to realise that both natural and social sciences are concerned with qualitative as well as quantitative methods.

It is not possible to formulate a correct quantitative generalisation about the behaviour of an internal combustion engine without a qualitative specification which excludes the possibility of confusing the topic under discussion with the behaviour of a grandfather clock. So it is not true to say that the method of the natural sciences is purely quantitative. *All* sciences are concerned with specification of laws of behaviour. Some laws of behaviour are relevant to idiosyncrasies of socially organised mankind, others to idiosyncrasies of molecular orientation in plastic products. Either way they involve preliminary qualitative specification of the domain of reference. Either way, the aim should be to give them as much quantitative precision as is practicable.

Our first task then would be to examine profitable fields for the study of human relations with a view to :

(*a*) recognition of available methods for attacking them ;
(*b*) a clearer understanding of the extent to which people trained in the natural and social sciences can severally contribute to such studies ;
(*c*) examination of the adequacy of existing methods of training in our universities to development of fruitful themes ;
(*d*) the relevance of investigable topics to pressing social needs in the period of post-war reconstruction.

The study both of the natural and the social sciences is departmentalised. The departments

into which the former fall may be defined by subject-matter, e.g. botany, or by function, e.g. physiology. Owing to the close interweaving of social life the departments of the social sciences are mostly defined by function. It is customary to speak of pure and applied natural sciences ; thus we have pure entomology and applied entomology. The former studies insects irrespective of their importance to man, whereas the latter selects insect pests for study, and like most other applied sciences is composite in that it uses chemistry and pharmacology in the search for means of destroying pests. A similar distinction is sometimes made in the social sciences ; education and criminology have, for example, been called applied social sciences ; both, it will be noticed, are composite. The distinction between pure and applied science is, however, much less clear and much less important in the social than in the natural sciences ; less clear because no social fact is devoid of human interest ; less important because all social sciences can be applied to solve social problems, and indeed because most of those who undertake pure study have an eye to its application. Thus it seems best not to make this distinction in the case of the social sciences.

There is no need here to detail and define the various branches of the social sciences that have become specialised disciplines. Their practical interrelation and their relation to border-line problems is sufficiently indicated in the syllabus of training suggested in Section III. It should be stressed, however, that questions of value are outside the scope both of natural and the social sciences. Sciences ask what things are and how they work : they do not ask whether things are good or beautiful, but the fact that value judgments are outside the scope of science, whether natural or social, does not invalidate the relevance of such research to issues of pressing topical importance. We commonly accept certain social objectives, such as the health of the individual and the survival of the community, social security, efficiency of production and minimum standards of living, as targets of community endeavour. In so far as we do so, practical social problems (e.g. of reconstruction) are problems about *means rather than ends*. The study of social institutions should therefore be able to prescribe what social techniques are best fitted to promote acceptable ends. It must remain powerless to do so if there is no *co-ordination between research on human institutions and applications of discovery in the natural sciences.*

Medical research is prosecuted on the assumption that there exists a highest common factor of human needs, and that it can be assessed by the method of science. In so far as practitioners of the natural and social sciences can separately or jointly explore the field of common human needs, and on that basis clarify objective standards of human welfare, there is a real and expanding field for enquiries which, though, like all truly scientific research, indicative, are as much and as little optative as research on cancer or infantile diarrhœa. Furthermore scientific study of human behaviour in society *vis-à-vis* social incentives and social deterrents can clarify social judgments about means which are efficacious to bring about specific ends. Inescapably we modify our social valuations by doing so. While it is therefore true that the technique of scientific investigation is ethically neutral, it is not equally true that the outcome of scientific discovery is indifferent to ethical judgments nor that ethical judgments can be or need be wholly divorced from factual issues of the sort with which science (as defined above) deals.

From this point of view the relation of factual research in the social sciences and what are called *ethical* issues is on all fours with the viewpoint of the natural sciences. Moreover, many issues annually made the topic of ethical debate are open to factual examination, inasmuch as research can reveal what methods of organisation and what types of collective conduct lead to results in conformity with social ends widely accepted as targets of communal endeavour, or what types of training fit individuals to co-operate in pursuing them.

At the present day it is often said that the resources of science are not sufficiently used for the benefit of mankind, and in this there is no doubt much truth. One reason for this is that there is not enough applied science ; this is as true of the natural as of the social sciences, and is especially true of those fields the elucidation of which demands collaboration between social and natural scientists. Another and more important reason is that those responsible for political and social action are only to a very limited extent aware of and guided by such applied scientific knowledge as exists.

In short, the difficulty lies precisely within our terms of reference : in the interrelations of the sciences and in bringing the results of scientific research to bear on the formation of public policy.

III

Education in the Social Sciences and their Relation to the Natural Sciences

(A) the present situation

The training at present provided in the social sciences consists of the first degree courses in specific social sciences and instruction connected with higher degrees taken in these sciences. These include economics, psychology, anthropology, history, political science and sociology. There seems to be no general agreement of the relations of these disciplines to one another or of any one of them to what may be called the philosophical approach in the study of human relations. The Oxford 'Modern Greats' combines but scarcely integrates history, economics and philosophy and apparently ignores psychology. In Cambridge, economics, psychology, philosophy dwell in splendid isolation. The University of London awards degrees in each of the subjects mentioned above, but there are also degrees in groups of social studies. The B.Sc.Econ. combines certain compulsory subjects such as economics and economic history with a varied assortment of special or honours subjects, which are in themselves a group of subjects, e.g. history, government, sociology, geography, international relations. There is also the B.A. in sociology which includes social institutions, social psychology, social philosophy, sociological theories and methods, and a detailed study of an area or civilisation which normally is modern England. At Liverpool there is an honours degree in social science, at

Birmingham an honours degree in social and political science, and similar degree courses are found in most Scottish and modern English universities, usually made up of courses in allied departments without the organisation of a social science department. Virtually all universities and university colleges have 'social study' departments for the training of social workers and the subjects taught include economics, history, social and political theory, psychology and social administration. A diploma or certificate is awarded, but the standard is lower or the number of subjects required less than that for a degree. Practical experience is given of types of social work, but there is rarely training in research methods.

No attempt can be made here to inquire into the merits of the different degree courses which the universities provide in the social sciences. There will perhaps be general agreement that there is a strong case for establishing departments of social science in the universities where these do not exist, and for their expansion where they do; and that it is consequently urgently necessary to think out afresh what such departments should be concerned with, and how the various sciences involved should be related to one another.

(B) PLAN FOR A CO-ORDINATED SYLLABUS

The field peculiar to the social sciences involves issues of two sorts: (*a*) human society, (*b*) social biology and psychology. These should be co-ordinated, for they are interrelated and each has problems at the interface of natural science. Special training should also be given in (*c*) social philosophy and (*d*) methodology.

(*a*) *Study of Human Society and Institutions*

Under this heading we include (i) the natural history of social structure, i.e. types of human association and organisation—economic, political and voluntary; the comparison of the social structure and the urban and rural 'class,' and other distribution of the population, of different countries and the effect of geographical and material conditions. (ii) Connected with this intimately is the study of social function, i.e. the way in which the structure works, is regulated and sustained. This clearly involves a study of the actual operation of law, morals, and religion in society, and of other forms of social sanction and control, including the economic price mechanism. (iii) Dynamics of social change or the study of short- and long-range trends in the life of societies, and the conditions, often technological, underlying these trends.

These studies in close interconnection may be called sociology. It will be readily seen that for their proper development the help and co-ordination of many disciplines are required. For example, social change can be studied through history. Parts of the structure are, or should be, studied by other disciplines—e.g. political science (in so far as factual), and realistic economics. These should not be unduly isolated, but treated in relation to the rest of the social structure. In the study of social functions reference is made to law, morals, and religion. These, of course, have their own disciplines, but what is wanted here is a treatment of them from the point of view of the part they play in the life of societies: in other words, law not as studied by the lawyer, or religion by the theologian, but rather the sociology of law, morals, and religion. The task can only be successfully achieved with the co-operation of specialists willing to look at their problems as parts of an integrated social science.

(*b*) *Social Biology and Psychology*

These are ancillary and form a background to sociology. They deal with (i) the genetic basis of human behaviour, the influence of the quantity and quality of the population on social structure, and the converse influence of the social structure on the quantity and quality of the population; (ii) the needs and wants of man, his preferences and aversions, motivation and educability in various types of social organisation, the distribution of abilities and problems of recruitment.

The social sciences included in (*a*) and (*b*) all border, as was said above, on the natural sciences. At the periphery of (*a*) and the natural sciences we have the impact of technology on means available for satisfying human needs and on the forms of human organisation. At the periphery of (*b*) and the natural sciences we have the material basis of human inheritance, and of human efficiency, and the impact of modern medicine and so forth on the evaluation of human wants and needs.

It is not, of course, intended that the department of the social sciences should absorb any or all of the various disciplines referred to under (*a*) and (*b*), such as psychology, history, law, or anthropology, but only that it should seek to attract such members of these and other departments as are interested in the contribution their special discipline can make to the study of man in society. Furthermore, the question of the degrees which such a department might provide is left open. Several different selections from these topics might be made according to the interests and previous training of the students. Some of them might also be more suited for postgraduate than undergraduate study. What is claimed is that the various topics enumerated above do really belong together and that departments of social science should be so organised as to bring out this interconnection.

(*c*) *Social Philosophy*

'The formation of public policy' (to quote our terms of reference) involves questions not only of fact, i.e. of the actual conditions of social life, but also of values, i.e. of the goals or ends of human endeavour and of the just distribution of the means available for their realisation. Some of us have maintained that the social sciences should be ethically neutral. Great confusion has certainly resulted from the failure to keep distinct the study of society as it is and society as it ought to be. But though social science and social philosophy are different disciplines, both are necessary for an effective handling of human problems. If students are given no training in ethical analysis, they either rely on an unreflective ethics of their own, or else they hover between scepticism and dogmatism. They either conclude that moral judgments are not susceptible of rational analysis or they accept the dogma of their day, e.g. the view

now very fashionable that moral judgments reflect the needs of the dominant social class. In moments of crisis, that is, of profound conflicts of loyalties, the moral assumptions underlying conduct are put to the test, and the lack of systematic reflection becomes painfully evident in the tangle of contradictions then brought to light and the rapidity with which people move from one standard of values to another. It is essential that students should be given training not only in marshalling and correlating factual data, but also in weighing values and disentangling the value elements in complex social situations. In other words, the study of social science should be accompanied by a study of social philosophy, which for this purpose may be described as dealing with the ethical elements in social relations, e.g. the basis of political authority, the criteria of just law, the legitimacy and limits of the political use of force, the problem of conflicting loyalties, the moral basis of the family, of property and other social institutions. As was pointed out above, ethical problems raise issues of fact susceptible of analysis by the methods of natural science. Ethical judgments must take into account the potentialities of human nature, the basic needs of men, and the ascertainable consequences of different lines of action. Yet the needs of men are not biologically given facts. They change with changes in ideals, and, beyond the sphere of common or minimal satisfactions, they give rise to intricate problems of relative valuation. These problems require and permit of rational investigation, and it is of very little practical importance whether such investigation be labelled ' scientific ' or not. If no provision is made for their study the social investigator will be least equipped to tackle with detachment and method just those problems which have the strongest emotional appeal and in relation to which the fiercest contests are likely to be waged.

(*d*) *Methodology*

Training in methodology and the handling of social data, whether derived from field work or historical, archæological and anthropological records, should certainly include statistics, and perhaps also a logical analysis of the methods used in the various social sciences.

Research on human institutions can only reach results fit to be ' brought to bear on the formation of public policy ' (to quote our terms of reference), if research workers are carefully trained in scientific methods of investigation. Particular attention should therefore be given to methodology in the social sciences and some study made of parallel techniques in the physical sciences. This attention to the method of arriving at truth should not be isolated from the material studied but should run through the treatment of all the subjects listed above under (*a*) and (*b*).

The first degree examinations at present given in the various social sciences do not always succeed in discovering research talent. Undergraduates obtaining first-class honours are often found, later, to be incapable of research. The three-hour examination paper asking for written answers to five or so questions without recourse to reference material is normally the only type of test applied in British universities. Memory, sharp wits and dialectical ability is rewarded, while the power to sift evidence and to generalise from particular facts and events goes unrecognised.

To ensure selection of students capable of discovering the possibilities of a new situation and not merely of stating and refuting a case, methods of examination for the first degree should be more varied. A short thesis testing the students' use of materials and powers of presenting conclusions and defending those conclusions in seminars of fellow-students should count towards first-class honours. More weight should be given to achievement in seminar discussion and in exercises showing resourcefulness, enterprise and aptitude in experimentation. In short, there should be some equivalent to the laboratory work of the natural sciences.

When the student proceeding to a higher degree in any of the social sciences does embark upon a research thesis, he is at present often left unsupervised. The assumption, apparently, is that the technique of research will come naturally to him, and that in any case his work, to deserve a degree, must be original. Originality should certainly be encouraged and crowned in the later higher degrees such as the Ph.D., but the earlier Master's degree (M.A., M.Sc. or M.Comm.) might well be awarded to denote a supervised training in documentary or field research, and cogency in presenting conclusions from the materials gathered.

Though the student may not be aiming at a career of research, yet such education and examination in research technique will select and train him for intelligent enterprise and for powers of planning that are far more useful in practical social organisation of all kinds than the habits of memory, wit, and dialectic fostered to-day.

IV

A Council for the Social Sciences

The need for a Council to co-ordinate the results of scientific research on human institutions and human needs and to bring these results to bear on the formation of public policy may be considered under four heads. There is the need to co-ordinate the direction of research and the disbursement of funds devoted to social research ; there is the need to advise public and private departments and agencies on the co-ordination of methods of presenting data, of ensuring accuracy of data and of securing completeness of data ; there is the need for initiating and supervising the training for practical administration of civil servants and other persons charged with forming and carrying out public policy in the use of scientific methods and results ; and finally there is the need for publishing the results of research and information of interest to social science as a whole.

The four sub-sections which follow discuss each of these four types of need.

IVa. *Need for Co-ordination in Direction of Research and in the Disbursement of Funds*

There is an obvious need for an organisation representing all branches of the social sciences and holding fairly the balance between them, which shall be in a position to speak for social science as a whole. This is particularly important if we recognise the existence of border-line subjects

between the social and the natural sciences which have as yet little recognition. The practical problems with which society will have to deal in the immediate future are largely of this border-line nature involving the use of a number of sciences, natural and human. We may instance :

(*a*) Population resettlement after dispersion and evacuation.
(*b*) The managerial control of large-scale industry.
(*c*) Public policy on venereal disease.
(*d*) Anthropological studies bearing on colonial government.
(*e*) The use of natural resources for the greatest public benefit.

This type of study requires co-ordinated team work. Hitherto the tendency for individualist research workers to go along their own lines has been too great. In dealing with social research more organisation is required, more paid personnel and more funds for research. In fact, more funds are required in the social than in the natural sciences since a large number of workers is involved in social surveys, and publication of statistical findings is expensive.

The Committee are of the view that university authorities no less than the public in general grossly underrate the financial need of realistic social research based on the statistical approach, and that the need for large allocations to take advantage of an atmosphere propitious to realistic social research—particularly border-line disciplines—in the period of post-war reconstruction is a matter which calls for immediate planning.

The clearest example of a body created mainly to meet the need for co-ordination is the American Social Science Research Council. The Council, started after the War of 1914–18, began in quite a modest way, without offices and with the secretary described as ' Secretary to the Chairman.' It now has palatial premises in New York and a nationally recognised position.

Its development was encouraged by the great Foundations as a convenience to them, since it acted as an advisory body prior to their disbursements, and did much of the preliminary work of digestion of projected schemes. Its recommendations were usually acted on. Its secretary was permanent ; its chairman took office (by invitation) over a period of three years. The governing council, not directly concerned with research, consisted of about thirty members. The national learned societies, continentally organised, provided the basis for election to the council, each society sending a certain number of elected members to the council. Originally there were five learned associations—economists, sociologists, political scientists, statisticians, and anthropologists. Later the humanities were strengthened by the addition of the historians—only sending the same number of representatives as the others. The psychologists were also included. The result was what has proved a sound working organisation.

There has never been any suspicion of conflict with existing departmental institutes, such as the Institute of Economics, Washington ; the Institute of Government, Washington ; the National Bureau of Economic Research, New York ; or with the universities. Rather the over-all co-ordinating function of the Council has been quite distinct. The Council has contributed to the organisation of semi-governmental bodies without itself becoming implicated in politics.

Instead of approaching Government or being a governmental body, the Council has been consulted as a body of independent reputation. Thus it was invited to organise the survey subsequently called the Survey of Social Trends, to which Mr. Hoover allowed his name to be given. Again the Rockefeller Foundation approached it to carry through a survey of the working of the Eighteenth Amendment, the results of which were later taken over by the Wickersham Commission. It has probably been of more aid to the Government, in relation to public opinion, by not being part of the Government.

A body has been established of dignity, independent reputation, wide-ranging interests, great wealth and international prestige. From the point of the university scholar, desiring to embark on research, its professional and financial activities have been almost entirely beneficial. Its tendency has been to encourage the younger men and to encourage unorthodox research which universities might not care to risk.

In Britain the nearest approach at present to a co-ordinating body such as the Social Science Research Council is the *Consultative Conference on Social and Economic Research.*

Late in 1939 those organisations which were receiving grants from the Rockefeller Foundation to promote social and economic research were invited by the Foundation to take steps to avoid any overlapping of programme. In response to this invitation representatives of the Royal Institute of International Affairs, the National Institute of Economic and Social Research, Nuffield College (University of Oxford), the Oxford Institute of Statistics, P.E.P., the London School of Economics (University of London) and the Manchester Economic Research Section (University of Manchester) met together and eventually their meetings came to be called ' The Consultative Conference on Social and Economic Research.' In course of time they were joined by a member of the Reconstruction Secretariat and a member of the Office of the War Cabinet, who were invited to attend in order to promote contact between academic bodies and certain government departments in which economic and social investigations are in progress.

The Conference, as is shown by its title, is a purely consultative body and has no executive functions. Its whole purpose is the interchange of information, with the object of ensuring so far as possible that the energies of research workers and the expenditure of the limited financial resources available are not wasted by avoidable duplication.

The Conference has usually met thrice yearly under the chairmanship of Mr. A. M. Carr-Saunders, director of the London School of Economics and Political Science. Accommodation for the meetings of the Conference and secretarial assistance have been provided by the Royal Institute of International Affairs, while the National Institute of Economic and Social Research has undertaken the preparation of a *Register of Research in Progress or in Plan.* An editorial advisory committee for the preparation

of this Register has been set up under the chairmanship of the Chairman of the Conference, its other members being Dr. W. C. Dickinson of London School of Economics, Dr. E. J. Lindgren of the Royal Institute of International Affairs, and Mrs. F. S. Stone of the National Institute of Economics and Social Research, who also acts as editor of the Register.

At the meetings of the Conference the *Register of Research in Progress or in Plan* is examined, additional information collected and scholars and research workers are assisted to get into touch with each other. The meetings have also afforded an opportunity for the discussion of matters of common interest.

There is general agreement among the representatives meeting at the Conferences that the opportunities for personal contact have been useful and, further, that the compilation of a *Register of Research in Progress or in Plan* in the economic and social sciences has proved to be of practical value. It has been felt, however, that the Conference would be still more useful if its representation were enlarged. A first step in that direction has now been taken, and the following institutions and organisations have accepted invitations to send representatives to the Conference meetings :—

Industrial Health Research Board of the Medical Research Council.
Institute of Education (University of London).
Institute of Public Administration.
Institute for the Scientific Treatment of Delinquency.
Institute of Sociology.
National Institute of Industrial Psychology.
Pilgrim Trust.
Population Investigation Committee.
Royal Anthropological Institute.
Royal Economic Society.
Royal Geographical Society.
Royal Statistical Society.
Sir Halley Stewart Trust.

These additions to the membership of the Conference bear witness to its informal nature and to the development of its increasingly representative character. As a further step towards this end the next issue of the *Register of Research in Progress or in Plan* will endeavour to include information covering the research work being carried out in all university research departments, including those departments which, while not formally constituted as research divisions or sections, do in fact plan the prosecution of organised research as part of their normal university activities.

IVB. *The Need for Advice on the Preparation of Official Social Statistics*

If scientific research on human institutions and human needs is to be brought to bear on the formation of a practical public policy such research must be founded on accurately recorded and measured facts and comparison of facts. The main sources or possible sources of such facts to-day are the public documents issued by Government departments. No private agencies have the necessary finance and staff to collect and tabulate the mass data required. Research into human institutions and needs must therefore rely upon official censuses of the situation from time to time, and official periodical returns, such as those for births and deaths, or for imports and exports.

The extensive field covered by Government data to-day may be realised by the accompanying table, giving a brief outline in parallel columns of the contents of the British and American official Statistical Abstracts. The order of subjects is that of the British Abstract for 1937, but the number of the corresponding American section is given in brackets.

Scope of Official Statistics : Statistical Abstract Subjects

U.K. (1939).	*A. Non-Economic*	*U.S.A.* (1941) [2]
I. Climate.		Climate (7).
II. Population, Natural Increase and Migration.		Area and Population (1). Vital Statistics (3). Migration (4).
III. 1–6. Vital Statistics.		
7. Parliamentary Electorate.		Congressional Representation (part of 8).
8. Houses and Buildings.		Construction and Housing (34).
III. 9. Education.		Education (5).
III. 10–12. Health Insurance, Pensions, Poor Relief.		Social Security (part of 15).
13. Lunacy and Mental Deficiency. 15. Justice, Police and Prisons.		Defectives and Delinquents (2).
III. 14. Control of liquor.		
IV. Defence.		Military and Civil Services (part of 8).
	B. Economic—General	
III. 16–20. Labour.[1]		Part of Social Security (15). Wages, Hours and Employment (14).
IV. National Finance.		National Government Finances (9).
VI. Local Government Finance.		State and Local Government Finances (10).
VII. Banking Currency and Wholesale Prices.		Banking and Finance (11).
VIII. Provident Associations, Life Assurances, Joint Stock Companies, Patents and Insolvency.		Income Expenditure and Debt (12). Prices (13).

[1] The Abstract of Labour Statistics covers official statistics under this head in greater detail.

[2] Public Lands or Parks (6 and 35 in U.S. Abstract) has no British equivalent.

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C. Economic—Particular Industries

	Irrigation and Drainage (24).
IX. Agriculture and Fisheries.	(25–30).
X. Industrial Production.	(32).
XI. 1 and 2. Mining and Metal Products.	(31).
3. Gas.	
4. Electricity.	(18).
XII. Transport.	
1. Communications.	(16) (17).
2–6. Transport.	(19) (20) (21).
XIII. Trades and Commerce.	(22) (23) (33).

The Presentation of Official Data

If the Government is overwhelmingly the most important source of social data to-day it is particularly important that government data be presented in a form which will facilitate the comparisons that are necessary for drawing useful conclusions. Such comparisons may be (1) of the same type of fact between different periods in order to trace changes and trends, or (2) may be comparisons of different characteristics relating to the same item in order to trace relationships. Both these sorts of comparison, so far from being facilitated, are made exceedingly difficult, and sometimes impossible, through the methods adopted by official compilers.

1. Obstacles put in the way of the *study of changes* are mainly due to a lack of continuity in definition. This lack of continuity may be due in turn to an actual change such as new political boundaries, national or local, or may simply be due to a change in the official schedules and classification. Unfortunately the official, however conservative he may be in other matters, has tended to be a revolutionary when it comes to altering his own ways of classification. It is, for example, impossible to compare in detail any English Census of Population with any other in respect of distribution of occupations owing to continuous changes in the official categories.

When the alterations are due, not to the census-taker's fancy, but to the changes in the facts such as alteration in boundaries, the changed facts should be set forth succinctly and some estimate made of the figures that would have appeared had no alterations been made.

2. Obstacles put in the way of research into the characteristics of the same item are usually due to a lack of uniformity and standardisation in the definition of the item.

The outstanding case of this lack of standardisation is in the classification of industries for the Census of Production, for the Census of Population, and for the Ministry of Labour, respectively. The research worker may wish to discover how far an industry that is localised is more or less likely to be made up of large plants than a dispersed industry. A satisfactory measure of localisation can best be obtained from the Census of Population; a satisfactory measure of the prevailing size of plants can only be obtained from the Census of Production. But, alas, a considerable proportion of the industries distinguished by the Census of Population have no equivalent in the Census of Production and *vice versa*. The Census of Production, for example, knows no separate carpet industry, though the Census of Population does; while the Census of Population knows not the distinct 'Finished Brass Trade' described by the Census of Production. Again, in the Census of Production, ink, gum, and typewriter requisites are classed together; while in the Census of Population ink is in one division of chemicals, gum in another, and typewriting requisites are part of the paper industry, and not in chemistry at all. The Ministry of Labour has its own classification of industries quite independently of the Census of Population and differing considerably from the Census of Production. Even when an industry has the same name in the three official classifications it will often be found that the number of workers counted in the different censuses come to quite a different sum in the same year. In fact the similarly named industries seem to have different boundaries.

Official censuses differ also in the simple matter of dividing up the country into regions. The North Riding for example is joined to Northumberland and Durham in the Census of Production, but with Cumberland and Westmorland in the Census of Population.

Clearly any research worker wanting to compare the size of plants given by the Census of Production with the localisation of the same industry given by the Census of Population and perhaps also the industry's liability to cyclical fluctuation, best given by the Ministry of Labour employment index, will have many officially imposed obstacles to overcome before he can get anywhere near his theme. It is no wonder that the realistic study of such relationships, important though they are, has never been carried far in this country. And international comparisons are hamstrung of course by a still greater lack of standardisation.

The Accuracy of Official Data

Research based on official data is not only impeded by methods of presentation; the accuracy of the data themselves may sometimes be questionable. This possibility arises in one very important line of enquiry, that seeking the real control of Joint Stock Companies and hence the real seat of control of the majority of British businesses. At Somerset House a file is kept of all shareholders (and the total of their shares) in British Joint Stock Companies, which is open to public inspection. This file should enable the seat of control to be found more satisfactorily than Berle and Means were able to do for America,[1] where such a file does not exist. Unfortunately nominee shareholders and other devices are permitted to cloak the name of the true beneficiary and to

[1] See *Modern Corporation and Private Property*, New York, 1934.

hoodwink the searcher after truth. Presumably the file was legally set up to display the truth, and advice from a strong representation to-day should help materially in stopping circumventions of the law.

Omissions from Official Data

In spite of the wide scope of present official sources of information, many possible sources that the government could open up still remain closed. An outstanding omission is a Census of Distribution parallel to the Census of Production. Such a census has been discussed and carried out in the United States since 1929 and has been extended to all forms of business. The absence of such a census is seriously impeding attempts to deal with the retail trade during the war, but the trade itself has always been lukewarm about a census. A strong body, representative of social scientists, would probably give the most effective 'prod' to the government of the future towards instituting a Census of Distribution. The same is probably true in filling other gaps in official sources, for example in vital statistics.

IVc. *Need for Initiation and Supervision of Practical Training Linking up with Definite Careers*

The syllabus given in Section III is planned for a general course in the social sciences. Refresher courses should also be initiated for training in the social sciences under the control of a council of wide experience. For particular purposes such as training for a specific career, practical courses need to be initiated and supervised, and linked up to the career in prospect. Among these purposes may be mentioned :

1. The training of colonial officers. The Royal Anthropological Institute has, we understand, been urging the need for more training in sociological investigation. Basing their case on Lord Hailey's *African Survey*, they note his contention that 'there has developed a general recognition that policies which do not take into account the nature of the native societies to which they are applied are apt to provoke unforeseen and unwelcome reactions.'

Lord Hailey instances the lack of experience in the technique of investigation, and adds that the administrative officer 'is often compelled to confine himself to the more immediate and obvious aspects of the subject into which he is inquiring, and is unable to consider its wider relations in the social or economic life of the community.'

The following passages are worth quoting from a recent memorandum of the Institute :—

'In the field of native education social anthropology is of great importance. In any colony in which the policy adopted is to fit the educational system to the needs of the native society, a thorough knowledge of the structure of that society and of the native culture, such as only anthropological research can provide, is indispensable.'

'The majority of the native societies in our colonial territories are still anthropologically unexplored. The first need, therefore, is for general studies to be made of as many as possible of the tribes whose social organisation is still unknown.'

'It cannot be too strongly emphasised that, if funds allocated for anthropological research are to be economically and effectively used, the work must be entrusted to persons who have been thoroughly trained in the theory and methods of the science. Whereas no colonial government would appoint an untrained man to study the geology or the vegetation of a colony, it is still sometimes thought possible to meet the need for anthropological research by allowing busy officials short periods of freedom from their ordinary duties in which to make inquiries into native custom and social organisation.'

2. Many civil servants, as pointed out by the Committee of the British Association on Post-war University Education, would benefit greatly by attending a university course in the social sciences within a few years of their entry into the service. That Committee is engaged in working out a curriculum for the purpose, but clearly it would be an advantage to have an organisation set up to initiate, revise and supervise these courses in relation to the needs of the service.

3. Training in social medicine. The attention of the Committee has been drawn to the interim report on Medical Planning Research appearing as a supplement to the *Lancet* of November 21, 1942. This report envisages liaison research and training between the social and the natural sciences, which badly needs organising.

4. Training for social work. In describing the present situation (Section 3A) it was mentioned that virtually all British universities and university colleges have departments for training in social work, such as case-work, child-guidance, youth leadership, and industrial welfare. The demand for trained social workers has expanded considerably during the war and is likely to continue to expand after the war.

The course of training given in those departments would gain considerably if there were regular university lectures on sociology, social biology and social psychology, which students in training could attend. Many types of social service, particularly those involving personal contacts, require a knowledge of the foundations of the normal human being's behaviour and of the building of his character and personality. Discussions of fundamental factors in behaviour—beside inherited characteristics, e.g. childhood experience and family relationships—are at present lacking in most British universities. Their initiation would serve to link the practical personal-contact training of students with the more academic teaching given in economics, psychology and social administration.

IVd. *Need for Publication of Information and Results of Research*

Any newly instituted council for the social sciences should prepare an index of books, institutions and movements dealing with social problems, and possibly of individual experts in all foreign countries. The body responsible for such an index should also have the machinery for ensuring that the index would be used. Foreign institutions and experts should be apprised of work being done in Britain, and British institutions and experts of work being done abroad. In this country the most important contributions to the quantitative study of social phenomena in recent times have been made in connection with the various

forms of social surveys. From the point of view of methodology their contribution has been chiefly in two directions. First they attempt to set up certain *standards*, such as Rowntree's 'Human Needs Standard,' approximation to which by individuals or groups is then measured. Second, they have sought to perfect various *sampling methods*, which have enormously simplified the task of securing the necessary data. The surveys have, however, in the main confined themselves so far to the study of very few social conditions, and for the most part they have concerned themselves with the working classes only.

Apart from the social surveys an interesting use of quantitative methods has been made in the study of crime. Here the work of Professor Burt (*The Young Delinquent*) deserves special mention, first because it must be among the earliest to make use of control groups for comparison and, secondly, because of the various devices he develops for estimating the relative importance of the numerous factors leading to criminal behaviour, thus throwing light on the general problem of social causation. There are plenty of examples of a tendency in Britain to ignore what is being done in other countries in this connection. We are very inadequately informed concerning social investigations in the U.S.S.R., especially of its anthropological work among the various races of the Union. We also know little of the elaborate methods adopted in the United States for collecting and collating vital statistics carefully indexed for comparison between different years and different towns. There is growing up a whole body of methods to which the name 'sociometrics' is assigned and to the elucidation of which a journal entitled *Sociometry* is devoted. Briefly, American sociologists have attempted to construct scales for the measurement of a great variety of social phenomena. The best examples are the following :—

Scale for the appraisal of health work of different communities ; Scales for measuring socio-economic status ; and Racial Distance Scales.

It will be seen that two kinds of sociometric scales are being developed. The first deals with aspects of communal life or institutional behaviour, while the second is more concerned with the social behaviour of individuals. Scales of the latter type are well known to psychologists in this country, but little attention seems so far to have been paid here to the scales used in the study of societies and their institutions.

Apart from the international exchange of information, there is a crying need for a journal that will publish in some detail results of statistical research undertaken in Great Britain. Articles published in the journal of the Royal Statistical Society may be taken as a model, but the journal is largely devoted to mathematical method, and cannot find room for enough of the positive results of social research. Other journals in the social sciences, such as the *Economic Journal*, *Economica*, *Politica*, the *Sociological Review*, the *Review of Economic Studies*, *Oxford Papers*, the *Economist*, are not able to publish more than short articles, usually without detailed statistical tabulations.

Partly, if not wholly, as a result of this situation, the research worker in Britain, who is primarily concerned with the discovery of new information about social phenomena does not enjoy a prestige or influence among his colleagues comparable with that of the research worker in the natural sciences. The young research worker who undertakes factual enquiries in the social sciences does so with proportionately less hope of gaining the respect of elders or of getting promotion and consequent enlargement of opportunities. For the copious means of publication which minister to the circulation of discoveries in the natural sciences, assure the prestige of those most active in carrying them out, bring their names and work before the attention of their colleagues and provide the teacher with means of keeping abreast of new techniques as well as of new results, are denied to those who now take up factual social research as a career.

From every point of view poverty of available means of publication, indeed the absence of any medium of publication *exclusively* devoted to factual research in the social sciences is of pivotal importance, and that for three reasons. First, because the young research worker with gifts and inclination to carry out such work has *no assurance* of the wherewithal for making the results of it available and of getting proper credit for work accomplished. Second, because there is no *norm* of publication to act as a brake on disputatious writing insufficiently supported by new data. Third, because there is no source to which research workers undertaking work in a particular field, or teachers training young research workers, can turn for a *comprehensive view of current and recent research* of a factual nature. In short, the social sciences are impoverished by the lack of the three types of publication which minister to the progress of all the natural sciences. These are :

(*a*) the specialist journals such as the *Journal of Genetics*, or the proceedings of academies such as the *Proceedings of the Royal Society*, exclusively devoted to the results of new and original research of a factual nature, excluding disputatious matter other than conclusions arising directly out of the new material presented ;

(*b*) topical abstracts such as *Chemical Abstracts*, *Physiological Abstracts*, which issue monthly *complete* summaries of all papers published in all journals of type (*a*) within a given field on an international basis ;

(*c*) quarterly reviews such as *Biological Reviews* and year-books which summarise progress in particular fields, with bibliographies on the basis of what (*a*) and (*b*) contain, but only as the accumulation of new data necessitate or make appropriate the choice of the selected topics.

In the natural sciences, specialist societies and academies exist to encourage the production of publications of any or all of the above within more or less extensive fields of specialisation. Sale of the journals to members or fellows is a guarantee of financial stability. They create a standard of excellence by which others can judge who are foremost in original work. They have started always and at all times by the free association of individuals actively engaged in research ; and they have raised their initial fund by joint subscription, the formation of limited liability companies and subsidies from public foundations.

They admit no delegate members representative of other societies, universities, institutes, or government departments. The creation of machinery of publication and preliminary announcements of results of work in progress is in fact the *nuclear* activity of all the academies of the natural sciences. By appointment of their own delegates to foundations which allocate funds for research, to universities and to institutes, they exercise more or less influence on educational policy, the co-ordination of research carried out in institutes and the disbursement of funds available for it; but they have gained such influence by the prestige of their publications. No competition or friction exists between one and another, because an academy and perhaps the majority of scientific societies come into existence only when the need for providing a new mouthpiece for research is clamorous.

Our deliberations have shown that the need of the social sciences is clamorous for each of the three types of publication specified above. A British *Society for Factual Social Research* would usurp the function of no existing organisation, if it followed the example of the academies of the natural sciences by undertaking the task of providing for media of publication on a *comprehensive basis* embracing all types of social research under each of these three headings. Its inauguration would guarantee the removal of outstanding obstacles to the prosecution of social research of a factual nature, a due measure of prestige to the rising generation of research workers, and funds to active departments capable of carrying out such research. By its existence it would co-ordinate the most pressing needs of the social sciences, in so far as the social sciences are factual in their own right. By its existence it would bring together results of research in a form more accessible to those whose professional work lies in the field of influencing public policy about available means of achieving ends for which a large measure of agreement exists. It would promote the circulation of new knowledge on which it would be possible for the teacher and the expositor to draw. In the long run the circulation of such knowledge is a necessary prerequisite of effective popularisation of accredited research in the social, no less than in the natural, sciences.

It is therefore suggested as part of the conclusion of our discussions that we should give further consideration to the possibility of promoting such a society for Factual Social Research; and that we should give due weight to ways and means by which the natural sciences have made provision for needs of the same sort. If we can safely follow the guidance of the natural sciences, our task should be to explore the possibility of setting up an informal committee of like-minded individuals who have this end in view, and will co-operate in exploring means of raising the necessary financial backing by public subscription, or approach to international foundations.

The task of recruiting a personnel adequate to finance the publication of such a society should be relatively simple, because it could offer associative membership, not only to teachers in universities and extramural organisations, but also to statesmen and higher civil servants. It might well attract sufficient funds from this source, and from such public foundations as could be persuaded to support it sufficiently to pay the salary of a whole-time secretary.

IVE

The urgent needs presented in the foregoing section, together with the general need for some organisation to represent British social science internationally, call for the constitution of a British Council for the Social Sciences.

The social sciences, though independent of the natural sciences, have, as pointed out in Sections I and II, many mutual links of matter and method. The British Association for the Advancement of Science may therefore well play a large part in making appointments to the Council. It is suggested that the five sections of the Association dealing partly or wholly with human institutions (geography, economic and statistical science, anthropology, psychology, and educational science) should each appoint one member, and the Division of the Association for the Social and International Relations of Science should appoint four—provided that two should definitely be sociologists. The reason for this provision is that the British Association has no sociological section, and sociology, as envisaged in Section IIIB, should certainly be strongly represented on the Council.

It is further suggested that among the institutions and organisations that have sent representatives to the Consultative Conference on Social and Economic Research (described in Section IVA above), those should appoint a member that are either recognised learned societies, or that conduct or supervise social research on any considerable scale. University departments would only be represented if these departments are responsible for *considerable* research especially in connection with training schemes such as those outlined in Section IVC. The new society for Social Research suggested in Section IVD would naturally be represented. Possibly the Royal Society might send a liaison member.

The proposed Council should be independent of the Government and should not admit Government nominees. But since part of the Council's functions will be to advise on the preparation of official statistics, as outlined in Section IVB, it is suggested that the Council have power of co-option which could be exercised in the case of a limited number of officials with special knowledge of the administrative problems of fact finding.

Like the American Council of the Social Sciences, described in Section IVA, the Council should have a permanent secretary with a chairman invited for a limited period.

To summarise: the membership of the British Council of the Social Sciences would number from thirty (the size of the American Council) to forty members, with preference for the smaller number. The number would be made up of representatives from the following organisations:

(*a*)	Five British Association Sections	5
(*b*)	The Division for the Social and International Relations of Science	4
(*c*)	The new Society for Social Research	1
(*d*)	The Royal Society	1

(*e*) Original members of the Consultative Committee . . .	7
(*f*) Enlarged membership of the Consultative Committee (? less those not engaged in social research or training)	7 to 13
(*g*) University departments engaged in social research not included in (*e*)	3 to 5
(*h*) Co-opted members	2 to 4
	30 to 40

The initiative in calling together the Council should, it is suggested, rest with the Council of the British Association.

(*Note.*—The foregoing recommendations will be considered by the Council of the British Association in due course.)

CO-OPERATIVE SYSTEMS IN EUROPEAN AGRICULTURE

Report of a Conference held by the Division for the Social and International Relations of Science, April 16–17, 1943

The Division for the Social and International Relations of Science held a Conference in March, 1942, on European Agriculture: Scientific Problems in Post-war Reconstruction, the transactions of which were published in *The Advancement of Science*, No. 6 (July, 1942). Following up this important topic, the Divisional Committee decided, early in the present year, to summon a further Conference which is the subject of the present report. By the generous permission of the Royal Institute of International Affairs, this Conference was held in Chatham House, St. James's Square, London, the headquarters of the Institute. Its genesis was explained by Sir Richard Gregory, Bt., F.R.S., President of the Association, in the opening statement which follows. For the rest, the communications received will be published in full in the *Year Book of Agricultural Co-operation* of the Horace Plunkett Foundation, to whose friendly collaboration the success and interest of the Conference was very largely due. A summary report is therefore given below; it is reprinted from *Nature*, May 8, 1943, with the kind consent of Miss Margaret Digby, the writer, and the editors of that journal.

Sir Richard Gregory, Bt., F.R.S., said: Eighteen months ago many contacts of science with government, the primary needs of human life, and planning to provide them, were described with authority at a Conference on Science and World Order held at the Royal Institution nearby. At that Conference, in which representatives of twenty-two of the Allied Nations took part, the view was strongly expressed that some of the main matters brought forward should be given particular attention by further assemblies or committees.

This suggestion has been carried out by the British Association through its Division for the Social and International Relations of Science which organised the original Conference. Two Conferences have since been held, one on European Agriculture: Scientific Problems in Post-war Reconstruction, and another on Mineral Resources and the Atlantic Charter. The present Conference on Co-operative Systems in European Agriculture has been convened in order again to bring together factual contributions upon subjects of especial importance in relation to post-war reconstruction.

The United Nations are now co-operating with the single purpose of overcoming their common enemies and thus to save a large part of the civilised world from conditions of slavery. The links which bind these free peoples together can be strengthened during this conflict by considering internal conditions and external opportunities of common interest in the economic production and distribution of the needs of life. Co-operation means working together for a particular purpose and in free association, whether for the exchange of goods and services or for national or international objects.

The larger the number of individuals or communities which thus combine to ensure mutual aid and trade, and the right adjustment of benefits to efforts, the stronger and the more stable is the federation, whether a co-operative society or an organisation of a State or number of States. There are many difficulties to be overcome before a commonwealth of the chief nations of the world accepts all that is implied in co-operative principles as generally understood, yet there is every reason to hope for, and expect, such a combination of interests among the United Nations when they understand each other's social problems and needs. The contributions to the present Conference should greatly assist in promoting this end.

No more appropriate place exists for a Conference of this kind than this Hall of the Royal Institute of International Affairs in Chatham House, which has for two days been courteously placed at the disposal of the British Association by the Council of the Institute. The announcement made yesterday of the transfer of the Foreign Research and Press Service of the Institute to the Foreign Office is a welcome and timely national recognition of the value of the researches undertaken by the Institute. The communications made to this Conference similarly represent results of enquiries and experience relating to social and international problems in which science and

technology are the chief factors of their full solution.

Sir John Russell, F.R.S., in his opening address, recalled how speakers at the previous conference, confronted with the agricultural alternatives of national self-sufficiency or a high standard of living, and of large or small farms, had, almost without exception, declared for the small farm and a high standard of living, especially of nutrition. The present conference accepted, and would have to deal with, the consequences of that decision. The disadvantage of the small farm is the overwhelmingly hard labour it demands, which bears particularly heavily upon the women. The small farm lacks machinery to lighten that toil, it lacks the capital needed to carry the farmer through the long cycle of agricultural production, and it is frequently burdened with debt. Methods of marketing are primitive and wasteful. It is the testimony of practical men that co-operation has provided a remedy for these evils. It has in addition given a technical training to the small farmer, raising his standards of cultivation and putting him in touch with modern knowledge.

The first session was devoted to the experience of Western Europe, beginning with the British Isles. **Mr. J. W. Hewitt,** himself a farmer and the chairman of a farmers' co-operative society in the west of England, took the co-operative supply of agricultural requirements as his main theme. He showed the large part which agricultural co-operative societies play in the handling of requirements such as seeds and feeding stuffs, grown by one set of farmers and used by another, and instanced, in particular, the distribution of the famous Aberystwyth strains of grasses and clovers and of 'once grown' seed potatoes. He looked forward to the end of the War and the urgent call from the devastated countries of Europe for agricultural requirements and supplies of all kinds, which it would be the great privilege and very pleasant duty of British farmers to meet with abundant supplies of the best qualities of seeds, seed corn and seed potatoes.

The application of co-operation to the problems of the Scottish crofters, the nearest approach to a peasantry to be found in the United Kingdom, was described by **Mr. C. J. M. Cadzow,** secretary of the Scottish Agricultural Organisation Society. He described how, following on the widespread failure of the crofters' potato crop in 1938, his Society had undertaken the distribution of seeds and fertilisers through the clerks to seven hundred grazing or township committees. All requirements were those recommended by the agricultural colleges as suitable to the district concerned. The Society had also arranged for the sale of the crofters' wool. The co-operative movement in Ireland, the remarkable pioneer work of Horace Plunkett and his associates guided by the formula 'Better farming, better business, better living,' and the world-wide influence of the movement, great out of proportion to its material achievements, were described by **Miss Margaret Digby.**

M. André Dulin, of the French National Committee, described the part played by agricultural co-operation in France in the provision of credit, both individual and collective, in insurance, the provision of agricultural requirements and in the processing and marketing of agricultural produce. He looked forward to the position of French agriculture at the end of the War, with soil impoverished and overrun by weeds, livestock and machinery diminished and labour reduced, since returning prisoners would be physically unfit to make much immediate contribution. It was likely also that experience of the failure of all the boasted reorganisation of agriculture by the Vichy Government would have bred pessimism and suspicion of all State regulation. On the other hand, sheer necessity has brought much informal co-operation in the use of implements and transport facilities. The hope of the future lay in the professional reorganisation of agriculture on the lines of voluntary co-operation.

M. Borremans, agricultural attaché to the Belgian Embassy, concluded the session with a sketch of agricultural co-operation in Belgium under the leadership of the well-known Boerenbond Belge, with its simultaneous concern for technical advance and instruction, social welfare and economic prosperity.

The second session was devoted to the northern countries lying about the North Sea and the Baltic, all having in common a strong dairy element in their co-operative economy. The chair was taken by **Dr. C. R. Fay,** reader in economic history in the University of Cambridge. Agriculture in these countries, he said, is based on the family farm, but it is not a peasant economy; it is the family farm, commercialised, mechanised and specialised, and the conditions of its success are two: State guardianship of the land unit, which can neither be merged in the large estate nor fragmented into the dwarf holding, and co-operative economics. Adjustment to an export market is not the secret of Scandinavian success in co-operative organisation. It must be sought rather in the high intelligence of the participants, based on high education, in democratic feeling, and in the integrated and dynamic character of the movement. All this can be seen not only in the countries represented at the conference, but also in Finland and Iceland.

M. P. A. Moltesen, agricultural attaché to the Danish Legation, described the spontaneous origin of Danish co-operation and its specialised character, with one function for each type of society, and its corollary, multiple membership by each farmer, and the final linking of all societies in a national federation which exerts considerable influence upon the economic policy of the country. **M. S. Królikowski** (Poland) spoke of co-operation as the means by which the peasant farm can effect the difficult transition between self-sufficiency and participation in a capitalistic economy, and can combine individual land ownership and cultivation with collective action in purchase, manufacture and sale. Co-operation, again, is the best channel of technical instruction for the farmer and the means of stimulating him to adopt more scientific methods. Before the War, 50,000 students were accommodated in co-operative schools. During the War, though their educational work has ceased, there was reason to believe that the agricultural trading co-operatives are still in use and developing, since they were too strong for the enemy to destroy without an adverse effect on the production-level. After the War their part would

grow still more, in the organisation of food supplies and the replanning of agricultural economy. **M. A. Fjelstad,** minister in the Norwegian Cabinet, sketched the development of co-operation in Norway both in farming and forestry, where co-operative insurance and the organisation of a fireguard service have saved considerable national assets from destruction. He described how the already developed co-operative dairy system enabled the Norwegian milk marketing board to be organised from the bottom up and not, as in Great Britain, from the top downwards. **M. B. Gerritzen,** agricultural attaché to the Netherlands Embassy, spoke of the many-sided co-operative organisation of his country, the part it has played in the development of the famous market garden industry of the Netherlands, and its bold and successful entry into the beet sugar industry. In the discussion, other speakers referred to the co-operative movements of the Baltic States and Iceland.

A further session of the Conference was devoted to a somewhat different aspect of the immediate post-war problem, the emergency distribution of food. In this the farmers and their organisation have a part to play, since every country must rely fundamentally on the food which can be produced within its own borders. But in the first few months of liberation every European country will be dependent on emergency supplies hurried into its towns and industrial areas—sometimes even into its rural areas—from overseas. These supplies will have to be distributed, as will those delivered from the country as soon as normal transport has begun to work. Distribution in such emergency conditions may not be easy to improvise and the normal channels of trade may be blocked or unsuitable. In these circumstances, the existence of a consumers' co-operative movement, whether catering mainly for the industrial population, as in Great Britain, or of a rural character as in many Continental countries, may well be of the highest value to the relief administrator or newly restored national government. It has the machinery of distribution, it serves public ends and enjoys the confidence of its members.

Mr. J. McFadyen, of the Co-operative Wholesale Society, opened the session with an account of the experience of the British co-operative movement in distributing foodstuffs in periods and areas of heavy bombing. He described the way in which neighbouring societies have come to one another's assistance. In one case where all the bakeries of a city were temporarily put out of action, nearly two-thirds of the necessary supplies were sent in from the co-operative bakeries of other towns and distributed both to co-operative members and others. Repairs to co-operative premises anywhere were the immediate concern of a central C.W.S. building department. Dispersal of essential stocks is made easy by the wide network of co-operative societies and the mutual understanding which exists between them. This account of actual and recent experience was followed by a survey from **Mr. R. A. Palmer,** acting chairman of the International Co-operative Alliance, of the actual resources in productive and distributive machinery, as well as in membership, of the co-operative movements in Europe, resources which, in spite of the restrictive and in some cases even destructive action of the occupying enemy authorities, will, it is hoped, be available to those who have to administer the distribution of food in the first difficult weeks after liberation.

Precisely how difficult those weeks may be was made plain in an address by **M. J. Kwapinsky,** Minister of Social Welfare in the Polish Government, who described the appallingly low level of rations which have been in force in Poland for a long time past : rations of 600–800 calories daily for the Polish Christian population and of less than 300 calories for the Jewish populations, in both cases below minimum physiological need. Relief of the town populations of Poland would have to be given with all possible speed. The enemy has destroyed private trade, and controls food distribution largely through the pre-war co-operative system, which is dominated but not destroyed. The supervision of food distribution in the post-war period will have to be transferred to the revived Polish local authorities, but for actual distribution in emergency circumstances, the co-operatives would be the most elastic system with the necessary commercial knowledge and storage and transport facilities. On their commercial efficiency in collecting home-grown food, in which agricultural co-operatives would also play their part, would depend in large measure the successful mastery of the ' black market.' On the efficient distribution of food from abroad would depend the speed of agricultural reconstruction, since no reconstruction could be attempted until such phenomena as the reckless slaughter of livestock for food has ceased. These conclusions were reinforced on the administrative side by **M. R. Kreisky,** speaking for Czechoslovakia, and on the nutritional aspect of the problem by **Dr. Magnus Pyke** of the British Ministry of Food, who described the very interesting enquiry into nutritional conditions in an industrial suburb of Madrid, carried out by the Rockefeller Foundation in the summer of 1941. This, while access to occupied Europe was impossible, provided the best indication of the sort of conditions which are likely to be found among the liberated peoples. The main conclusion was that the fundamental condition was a shortage of calories rather than deficiency of any particular constituent. The diet was pitiably scanty but not grossly unbalanced.

At its last session with Sir John Russell, F.R.S., in the chair, the Conference returned to the agricultural and productive, rather than the distributive, aspect of co-operative organisation, and considered the experience of countries in Eastern Europe, Czechoslovakia, Yugoslavia, Greece and the Soviet Union. **Dr. R. Bicanic** (Yugoslavia) looked beyond the organisation of co-operation on the ' classic ' pattern of local and voluntary association, already developed with a varying measure of success in the different regions of Yugoslavia before the War. He envisaged a type of co-operation which would embrace the entire village community, deriving from the old Slav principle of the ' Zadruga,' or family group, which is still a living force. Such a village co-operative would not be a collective in the Russian sense, but it would carry out a complex of services usually divided among separate co-operative societies, local authorities or individuals, or in many rural

communities wholly neglected. A movement in this direction was developing spontaneously before the War ; the post-war task would be to foster and extend it. **Dr. F. Hodza** (Czechoslovakia) showed how the strength of the co-operative movement had been built up by voluntary effort in the days of Austrian and Hungarian rule, and how under the Republic it was able to take a leading place in national economy. **M. G. Polychroniades** (Greece) looked to the reconstruction of Greek agriculture and the raising of the peasants' standard of living through a much more extensive application of co-operative methods. **Dr. N. Barou** concluded the review of European experience with an account of the wholly different application of the co-operative principle in the Soviet Union, where collective ownership of land and collective application of labour have replaced the individual peasant farm and, with the increased size of the unit and the State control of banking and commerce, the ordinary economic functions of the co-operative have disappeared.

The final impression left by the Conference was of the strength, ubiquity and diversity of the co-operative movement in Europe, and of the extent to which it is, and will doubtless remain, the principal instrument of raising both the technique of European farming and the social conditions of the peasant.

GENERAL TREASURERSHIP OF THE ASSOCIATION

At a meeting of the War-time Executive of the Council held on January 12, 1943, the desire expressed by Professor P. G. H. Boswell, F.R.S., to retire from the General Treasurership of the Association was received with sympathetic regret. Sir Harold Hartley, C.B.E., M.C., F.R.S., was invited, and consented, to accept the Council's nomination as Professor Boswell's successor. This nomination was conveyed to the General Committee, which, on March 20, at a meeting held in the theatre of the Royal Institution on the occasion of the Conference on Science and the Citizen, appointed Sir Harold Hartley to the General Treasurership as from April 1, the date of the beginning of the Association's financial year 1943–44. The General Treasurer's Statement which follows, preceding the Account for 1942–43, is therefore that of Professor Boswell.

At its meeting on March 20 the General Committee unanimously adopted the following resolution :

' That the General Committee place on record its deep sense of gratitude to Professor P. G. H. Boswell, F.R.S., for his great services to the Association as General Secretary, 1931–35, and General Treasurer, 1935–43 ; as President of the Section of Geology, and Chairman of the Conference of Delegates of Corresponding Societies, and in other departments of the Association's activities.

' The General Committee remembers in particular his close and practical interest in the maintenance of Darwin's home, Down House, which is so honourable a trust of the Association.

' Above all, the General Committee thanks Professor Boswell for his careful control of the finances of the Association as General Treasurer, especially during the present period of stress.'

GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1942–43

In presenting the accounts for the year 1942–3, I need comment on only three points. First, a new item appears in the Balance Sheet, to wit, the legacy of £500 from the late Charles Davies Sherborn. The Council will doubtless allocate this sum in due course, but I would suggest that if credited to the Contingency Fund (which can only be expected to accumulate slowly), it should be more easily accessible than in General Funds. Next, there is a small balance on the Income and Expenditure Account. This favourable circumstance is due on the one hand to smaller disbursements to research committees, consequent upon the smaller number of applications under war conditions ; and on the other to the receipt of £200 towards publication costs, already gratefully acknowledged, from the Rockefeller Foundation through the Royal Society, and to the maintenance of annual subscriptions by many members, whose continued support during the war is highly appreciated. Thirdly, in the same account, it will be noted that no item appears, as heretofore, showing separately the expenses incurred by the Division for the Social and International Relations of Science, because the activities of the Association are at present practically restricted to the work of the Division, and almost all the expenditure shown under the heads of salaries, printing, office expenses and postage relates to such work.

As this is the last Account that I shall have the honour to submit to the General Committee, the occasion seems fitting for a brief review of the financial policy of the Association during the past twelve years, that is, since the Centenary Meeting. This period was marked by a considerable extension of the work of the Association, resulting in many new contacts ; and by efforts to stabilise the financial position (for which we were indebted in no small measure to the lead given by my predecessor, Sir Josiah Stamp, General Treasurer 1928–35). Apart from its purpose as an historical record, this review may be of use when future

policy comes to be considered, notwithstanding the likelihood that the war may mark the end of one phase and the beginning of another, of which the repercussions are not easy to foresee.

During its first hundred years the Association's financial provisions may be not unfittingly described as 'from hand to mouth.' When the attendance at Annual Meetings was large, grants to committees 'to report on the State of Science' were on a generous scale, but when the meetings were held in smaller centres or expenses were heavy, reduced grants for research were unavoidable. The fluctuation in membership, and therefore in income, from year to year made it unwise to budget ahead, even for a single year; consequently, the planning and continuity of investigations was seriously hampered. Furthermore, rivalry was inevitable when Sections had to strive for grants from a common pool; and many of our older members will be able to look back on Recorders' Meetings when much midnight oil was burnt during the long-drawn-out discussions that accompanied straitened circumstances. Added to the recurrent uncertainty about income came the demand for economy induced by trade depressions, particularly that of 1930 onwards.

In spite of these handicaps, our predecessors succeeded, mainly by the occasional investment of surpluses of income over expenditure, in building up the greater part of the present accumulated fund for general purposes. This fund (now amounting to more than £15,000), together with Sir James Caird's gift of £10,000 in 1912 and Sir Charles Parsons's gift of £10,000 in 1922, is the source of the Association's present financial health. Having regard to the difficulties of establishing and maintaining such a fund, it is not perhaps surprising that successive Councils have been reluctant to draw on these reserves for special purposes, since the effect would have been to reduce the much needed income derived annually from investments.

A perusal of the Annual Reports and Statements of Accounts for the past decade shows how the need for stabilising the finances has constantly engaged the Council's attention. Economies were introduced in order to reduce the costs of the Annual Meetings both to the Association and to its hosts; for example, presidential banners, elaborate badges, and expensive handbooks were no longer produced. In 1932, a five-year plan was introduced under which the Sectional Committees were invited to adopt a self-denying ordinance as regards recommendations for grant-aided research committees, in order that a Contingency Fund might be built up, with a view to supplementing in lean years the sums available for research. It was then agreed to limit the allocations to research committees from general funds to a total of £400 p.a. (as distinct from, and additional to, income available from special funds), and to reserve £500 p.a. for the Contingency Fund. However, it so happened that during the five-year period the balances were insufficient to provide the full allocation; and when the Fund reached £2,000, that sum was regarded as an adequate reserve.

The difficulty of acceding to the many requests for research grants had become more acute because certain changes in their nature had developed almost imperceptibly. Thus the regular grants to certain old-established committees,[1] amounting to quasi-endowment, while undoubtedly contributing greatly to the advancement of science, were at the same time reducing the Association's power to encourage new ventures. The remedy for this state of affairs, apart from an increase in the Association's general prosperity, would seem to lie in the discovery of new sources of help for those older committees.

Fortunately, since 1936 until 1939, each year saw a large Annual Meeting, with the result that the necessity for drawing on the Contingency Fund (or, as it now came to be styled, the Grants Equalisation Fund) has not yet arisen. Moreover, further favourable balances on the annual working since 1938 have enabled the Council to establish an additional Contingency Fund (now amounting to £1,588 19*s.* 7*d.*) which can be used to meet unforeseen and extraordinary expenditure. We may here note that the membership figures for the eight years preceding the war were: 1932, 2,024; 1933, 2,268; 1934, 2,938; 1935, 2,321; 1936, 2,067; 1937, 2,027; 1938, 2,983; 1939, 3,186: average 2,476. These figures are evidence of the widening of the appeal of the Association, for never before in its history had there been a continuous succession of even five years in each of which the numbers exceeded 2,000.

Mention should also be made of a new form of membership, with a minimum subscription of 30 guineas, which was introduced in 1934 with the object of giving corporate bodies a form of membership equivalent to ordinary life membership, the fee for which had been lowered to 10 guineas in 1932. By 1939 fifteen 'corporation members' had been enrolled and were sending their representatives to the annual meetings. It is to be hoped that many more industrial firms and other bodies will take advantage of this opportunity.

A further step in financial policy, designed to avoid substantial future liabilities, was taken in 1935–6, when a contributory superannuation scheme was introduced for members of the office staff (other than the Secretary, for whom a scheme was already in operation, although it was inadequate to provide an appropriate pension). By this means one possible source of anxiety to General Treasurers will be appreciably reduced.

In 1935–6 the incorporation of the British Science Guild with the Association brought with it an accession of membership and a capital fund of £3,431 9*s.* 1*d.*, the Association assuming certain obligations, however, which involve annual expenditure, such as the Norman Lockyer and Alexander Pedler lectures (in abeyance during the war), and liabilities in respect of former life members of the Guild.

In recent years expenditure on Down House has been under constant review, with the object of effecting due economy. Since the presentation and endowment of this property by Sir

[1] E.g., Naples Zoological Station Committee, founded 1876 (till 1937); Plymouth Laboratory Committee, founded 1886; Seismology Committee, founded 1895; Zoological Record Committee, founded 1923: and to these should be added Freshwater Biological Station Committee, founded 1930.

Buckston Browne in 1929, the calls made on the Association in respect of charges incidental to its acquisition, restoration and subsequent maintenance amounted to £3,751 up to the close of the financial year 1934–5. Thanks to the exertions of the late Sir Alfred Ewing and Lord (then Sir Josiah) Stamp, the Pilgrim Trust generously made grants of £150 p.a. for the five years 1933–7 to meet the annual deficit, and further tapering contributions of £150, £100 and £50 during the succeeding three years, 1938–40. The war-time economies introduced into the working and staffing have for the time being resulted not only in the balancing of the accounts, but have made it possible to set aside small sums to form a suspense or maintenance fund, although at the moment this amounts to only £122 12*s.* 7*d.* In view of the present rising costs, however, it is doubtful whether this improvement can be maintained, and it is less likely to be continued after the war, when the House should again be open to the public.

What of the future? In the matter of receipts, we should not lose sight of the fact that our income has decreased because of the reduction in interest from investments, mainly consequent on the repayment of certain relatively high-yielding stocks. This reduction is the less apparent in the accounts because it has been offset by additional income from new gifts and bequests, some of which, however, being ear-marked for special purposes, benefit general funds only indirectly, if at all. The spell of cheap money is not likely to end in the near future: rather, indeed, lower rates of interest on investments are to be expected. Of still greater import is the approaching extinction of the Yarrow Fund which contributes about £550 p.a. to our income and must, under the terms of the gift, be expended by 1947. The need for replacement of this source of revenue is already urgent. Another point for consideration is that if, after the war, the Association extends its contacts by holding meetings in smaller centres (and good reasons have been adduced for so doing), the large income from membership recorded in recent years is not likely to be maintained.

On the side of expenditure, the active policy pursued by the Division for the Social and International Relations of Science, which by fact-finding and discussion is greatly contributing to the solution of the post-war problems that face the Allied Nations, is already proving costly, and bids fair to be much more so in the future. The expenses of Divisional meetings cannot be met, like those of our normal Annual Meetings, from a local fund. The progress of this important work can only be maintained if substantial grants-in-aid are received from Government, industry, or private benefactors.

In conclusion, I desire to express my warm thanks to the General Committee, Council, and General and Sectional Officers for the kindness and encouragement extended to me during my tenure of office, first as a General Secretary from 1931 to 1935, and since then as General Treasurer. And I would also take this opportunity of gratefully acknowledging the assistance rendered by the office Staff, especially Mr. K. C. Pears, Chief Clerk and Accountant.

P. G. H. Boswell.

Balance Sheet, 31st March, 1943

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

		£	s.	d.	£	s.	d.
	GENERAL PURPOSES :—						
	Sundry Creditors	63	14	10			
	Amounts received in advance for publications	64	16	11			
					128	11	9
	Hon. Sir Charles Parsons' gift (£10,000) and legacy				12,000	0	0
	Sir Alfred Ewing's legacy				500	0	0
	Dr. C. D. Sherborn's legacy				500	0	0
	British Science Guild : Capital Fund				3,431	9	1
	Accumulated Fund				15,542	6	5
	Yarrow Fund						
	As per last Account	2,713	5	11			
	Add Profit on transfer of stock	20	2	2			
		2,733	8	1			
	Less Transferred to Income and Expenditure Account under terms of gift	450	3	7			
					2,283	4	6
	Life and Corporation Membership Compositions						
	As per last Account	4,090	19	2			
	Add Received during year: Life Compositions	73	10	0			
		4,164	9	2			
	Less Transferred to Income and Expenditure Account	15	0	0			
					4,149	9	2
	Grants Equalisation Fund				2,000	0	0
	Contingency Fund						
	As per last Account	1,465	8	0			
	Add Excess of Income over Expenditure for the year, on General Account	123	11	7			
					1,588	19	7
	Overseas Delegations Fund				781	3	11
	Secretary's Pension Fund						
	As per last Account	2,000	0	0			
	Add Interest on investment	27	19	9			
					2,027	19	9
[*44,972 17 8*]					44,933	4	2
	SPECIAL PURPOSES :—						
	Caird Fund						
	Capital as per last Account	9,702	10	2			
	Add Profit on repayment of India 3½% Stock	226	7	7			
		9,928	17	9			
	Revenue balance as per last Account . 243 19 1						
	Add Excess of Income over Expenditure for the year . 167 19 9						
		411	18	10			
[*9,946 9 3*]					10,340	16	7
	Mathematical Tables Fund						
	As per last Account	120	14	5			
	Add Receipts from Sales	41	3	8			
		161	18	1			
	Less Grant paid	5	0	0			
[*120 14 5*]					156	18	1
	Cunningham Bequest Fund						
	As per last Account	1,253	7	11			
	Add Income for the year	62	16	11			
[*1,253 7 11*]					1,316	4	10
	Toronto University Presentation Fund						
	Capital	178	11	4			
	Revenue balance as per last Account . 4 7 6						
	Add Income for year . 6 2 6						
		10	10	0			
[*182 18 10*]					189	1	4
	Bernard Hobson Fund						
	Capital	1,000	0	0			
	Revenue balance as per last Account . 130 19 4						
	Add Excess of Income over Expenditure for the year . 27 13 11						
		158	13	3			
	Less Loss on repayment of 4% Victory Bonds, transferred to Revenue Account . 36 3 1						
		122	10	2			
[*1,130 19 4*]					1,122	10	2
[*57,607 7 5*]	Carried forward				58,058	15	2

ASSETS

		£	s.	d.	£	s.	d.
	GENERAL PURPOSES :—						
	Investments as scheduled with Income and Expenditure Account, No. 1				44,593	7	11
	Sundry debtors and payments in advance				31	11	0
	Cash at bank				291	1	6
	Cash in hand				17	3	9
[*44,972 17 8*]					44,933	4	2
	SPECIAL PURPOSES :—						
	Caird Fund Account						
	Investments (see Income and Expenditure Account, No. 2)				9,928	17	9
	Cash at bank				411	18	10
[*9,946 9 3*]					10,340	16	7
	Mathematical Tables Fund Account						
	Cash at bank				156	18	1
[*120 14 5*]					156	18	1
	Cunningham Bequest Fund Account						
	Investments (see Income and Expenditure Account, No. 3)				1,240	12	4
	Cash at bank				70	12	6
	Debtor				5	0	0
[*1,253 7 11*]					1,316	4	10
	Toronto University Presentation Fund Account						
	Investment (see Income and Expenditure Account, No. 4)				178	11	4
	Cash at bank				10	10	0
[*182 18 10*]					189	1	4
	Bernard Hobson Fund Account						
	Investments (see Income and Expenditure Account, No. 5)				1,000	0	0
	Cash at bank				122	10	2
[*1,130 19 4*]					1,122	10	2
[*57,607 7 5*]	Carried forward				58,058	15	2

Balance Sheet, 31st March, 1943 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

		£ s. d.	£ s. d.
[57,607 7 5]	Brought forward		58,058 15 2
	Leicester and Leicestershire Fund, 1933		
	Capital	1,000 0 0	
	Revenue balance as per last Account . . 48 8 4		
	Add Excess of Income over Expenditure for the year . . . 4 4 2		
		52 12 6	
[1,048 8 4]			1,052 12 6
	Property Rehabilitation Fund		
	As per last Account	415 16 10	
	Less Excess of Expenditure over Income for the year	26 1 7	
		389 15 3	
	Creditor	2 10 10	
	Cash balance overdrawn	7 13 11	
[420 18 7]			400 0 0
	Radford Mather Lecture Fund		
	Capital	250 0 0	
	Revenue balance as per last Account . . 3 5 11		
	Add Income for the year 7 9 4		
		10 15 3	
[253 5 11]			260 15 3
	Down House		
	Endowment Fund	21,204 17 8	
	Library Fund	10 10 0	
	Suspense Account		
	Balance as per last Account . . 53 9 3		
	Add Excess of Income over Expenditure for the year . . . 69 3 4		
		122 12 7	
	Creditors	54 5 7	
[21,309 1 1]			21,392 5 10
[80,639 1 4]			£81,164 8 9

ASSETS (*continued*)

		£ s. d.	£ s. d.
[57,607 7 5]	Brought forward		58,058 15 2
	Leicester and Leicestershire Fund, 1933, *Account*		
	Investments (see Income and Expenditure Account, No. 6)	1,000 0 0	
	Cash at bank	52 12 6	
[1,048 8 4]			1,052 12 6
	Property Rehabilitation Fund Account		
	Investment (see Income and Expenditure Account, No. 7)	400 0 0	
[420 18 7]			400 0 0
	Radford Mather Lecture Fund Account		
	Investment (see Income and Expenditure Account, No. 8)	250 0 0	
	Cash at bank	10 15 3	
[253 5 11]			260 15 3
	Down House Account		
	Endowment Fund investments (see Income and Expenditure Account, No. 9)	21,204 17 8	
	Sundry debtors and payments in advance	72 5 0	
	Cash in hand	40 3 2	
	Cash at bank	75 0 0	
[21,309 1 1]			21,392 5 10
[80,639 1 4]			£81,164 8 9

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments, and the Bank have certified to us that they hold the Deeds of Down House.

Approved:
ROBERT S. WHIPPLE
EZER GRIFFITHS } *Auditors.*

W. B. KEEN & CO., *Chartered Accountants.*
224 Regent Street, London, W. 1.
June 9, 1943.

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1943

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£	s.	d.
	Investments at cost :			
	£24,510 0s. 2d. Consolidated 2½ per cent. Stock	18,296	7	6
	£1,000 0s. 0d. 3 per cent. Savings Bonds 'A,' 1960/70	1,000	0	0
	£5,268 19s. 0d. 3 per cent. Savings Bonds 'B,' 1955/65	5,268	19	0
	£879 14s. 9d. Great Indian Peninsula Railway 'B' Annuity £43	827	15	0
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54	5	2
	£8,069 13s. 6d. 3½ per cent. War Loan inscribed Stock	8,125	12	8
	£6,368 15s. 7d. 3½ per cent. Conversion Stock	5,304	8	11
	£4,184 18s. 2d. 3 per cent. Local Loans	3,073	12	2
	£1,000 0s. 0d. 4 per cent. Funding Loan	1,170	0	0
	£100 0s. 0d. 5 per cent. Great Western Railway Consolidated Pref. Stock	125	0	0
	£345 16s. 8d. 3 per cent. London County Consolidated Stock	347	7	6
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock	1,000	0	0
	[Value of stocks at 31/3/42, £49,456 14s. 3d.] (Value at 31/3/43, £50,105 9s. 5d.)			
[44,009 8 10]		£44,593	7	11
	Cash at bank and in hand	£308	5	3

EXPENDITURE

		£	s.	d.
	To Heat, Lighting and Power	35	17	6
	„ Stationery	133	0	8½
	„ Rent	1	0	0
	„ Postages	110	16	7½
	„ Travelling expenses	43	2	6
	„ Audit	31	10	0
	„ Subscription to Parliamentary and Scientific Committee	10	10	0
	„ Hire of meeting rooms	23	11	6
	„ General Expenses	114	3	4
	„ Salaries and wages	1,844	7	2
	„ Pension contributions	79	7	0
	„ Printing, binding, etc.	547	2	5
	„ Grants paid to Research Committees	10	0	0
	„ Division for Social and International Relations of Science *	—	—	—
	„ Air raid precautions at Burlington House	37	6	11
	„ War Damage Insurance (Contents)	6	0	0
	„ Balance, being Excess of Income over Expenditure, transferred to Contingency Fund	123	11	7
[2,918 13 1]		£3,151	7	3

INCOME

		£	s.	d.
	By Annual Membership subscriptions	451	19	0
	„ Life compositions : amount transferred on expiry of membership	15	0	0
	„ Sale of Publications 385 2 0			
	Less amount transferred to Mathematical Tables Fund 41 3 8			
		343	18	4
	„ Royal Society (Rockefeller Grant)	200	0	0
	„ Advertisements in B.A. publications	140	19	7
	„ Income Tax recovered	51	7	4
	„ Interest on investments	1,386	0	9
	„ Interest on current account	4	11	9
	„ Rental of accounting machine by Ministry of Supply	50	0	0
	„ Air raid precautions : amount transferred from Property Rehabilitation Fund	37	6	11
	„ Yarrow Fund : amount of capital transferred †	450	3	7
	„ Grant from Caird Fund towards expenses of Committee on Post-war University Education	20	0	0
[2,918 13 1]		£3,151	7	3

* The separate heading for the Division for the Social and International Relations of Science has become misleading and has therefore not been retained in the present account. Work in connection with the Division has formed the major part of the Association's activities during the year and the expenditure (largely printing, postage and stationery) is more suitably shown under the regular headings of the General Income and Expenditure Account.

† YARROW FUND

The amount shown in the Balance Sheet is the balance of a gift of £10,000 received from Sir Alfred Yarrow in September, 1926, to be used 'as the authorities controlling the Association may think best in the interests of science,' without restriction other than that the capital as well as income must be expended within approximately twenty years.

No. 2. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,627 0*s.* 10*d.* 3 per cent. Savings Bonds 'A,' 1960/70	2,627 0 10
	£2,100 0*s.* 0*d.* London Midland and Scottish Railway 4 per cent. Preference Stock	2,190 4 3
	£2,000 0*s.* 0*d.* Southern Railway 5 per cent. Preference Stock	2,594 17 3
	£2,716 16*s.* 6*d.* 3½ per cent. War Loan Inscribed Stock	2,516 15 5
[*Value of stocks at 31/3/42, £9,265 16s. 11d.*]	(Value at 31/3/43, £9,491 8*s.* 11*d.*)	
[*9,702 10 2*]		£9,928 17 9
	Cash at bank	£411 18 10

EXPENDITURE

	£ s. d.
To Grants paid (see Schedule)	230 0 0
„ Balance, being excess of Income over Expenditure for the year	167 19 9
[*364 14 4*]	£397 19 9

INCOME

	£ s. d.
By Dividends and Interest	284 14 9
„ Income Tax recovered	113 5 0
[*364 14 4*]	£397 19 9

Grants authorised, not yet drawn :—	£ s. d.
Seismology	100 0 0
Mathematical Tables	190 0 0
Zoological Record	50 0 0
Insular Faunas	10 0 0
[*190 0 0*]	£350 0 0

No. 3. Cunningham Bequest

A legacy received by the Association in 1929 in trust under the will of Lt.-Col. A. J. C. Cunningham, for the preparation of new mathematical tables in the theory of numbers ; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£1,187 6*s.* 10*d.* Consolidated 2½ per cent. Stock	653 0 9
	£300 0*s.* 0*d.* Port of London 3½ per cent. Stock, 1949/99	216 0 0
	£737 2*s.* 10*d.* Local Loans 3 per cent. Stock, at cost	371 11 7
[*Value of stocks at 31/3/42, £2,002 16s. 7d.*]	(Value at 31/3/43, £1,996 18*s.* 6*d.*)	
[*1,240 12 4*]		£1,240 12 4
	Cash at bank	£70 12 6

EXPENDITURE

	£ s. d.
To Balance, being Income for the year	62 16 11
[*70 13 5*]	£62 16 11

INCOME

	£ s. d.
By Interest	57 19 10
„ Income Tax recovered	4 17 1
[*70 13 5*]	£62 16 11

No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. From the income a presentation of two bronze medals each year is made, together with presents of books, to selected students in pure and applied science respectively.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£175 0*s.* 0*d.* 3½ per cent. War Stock	178 11 4
[*Value at 31/3/42, £184 13s. 9d.*]	(Value at 31/3/43, £185 10*s.* 0*d.*)	
	Cash at bank	£10 10 0

EXPENDITURE

	£ s. d.
To Balance, being Income for the year	6 2 6
[*10 3 0*]	£6 2 6

INCOME

	£ s. d.
By Interest	6 2 6
[*10 3 0*]	£6 2 6

No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost:	
	£50 0s. 0d. 4 per cent. Victory Bonds	55 10 5
	£601 9s. 0d. 3 per cent. Local Loans	508 6 6
	£416 0s. 11d. 3½ per cent. War Loan Inscribed Stock	436 3 1
	[Value at 31/3/42, £1,091 3s. 0d.] (Value at 31/3/43, £1,078 8s. 1d.)	
[1,000 0 0]		£1,000 0 0
	Cash at bank	£122 10 2

	EXPENDITURE	£ s. d.		INCOME	£ s. d.
	To Portion of cost of 3½ per cent. War Stock purchased representing interest	4 17 1		By Interest	23 11 0
	Loss on repayment of 4 per cent. Victory Bonds	36 3 1		„ Income Tax recovered	9 0 0
				„ Balance, being excess of Expenditure over Income for the year	8 9 2
[34 14 0]		£41 0 2	*[34 14 0]*		£41 0 2
	Grant authorised, not yet drawn:—				
	Insular Faunas	10 0 0			
[5 0 0]		10 0 0			

No. 6. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost:	
	£487 2s. 11d. 3½ per cent. Conversion Stock	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock	500 0 0
	[Value of stocks at 31/3/42, £1,035 0s. 10d.] (Value at 31/3/43, £1,037 6s. 3d.)	
[1,000 0 0]		£1,000 0 0
	Cash at bank	£52 12 6

	EXPENDITURE	£ s. d.		INCOME	£ s. d.
	To Grants paid (see Schedule)	30 0 0		By Interest	34 4 2
	„ Balance, being excess of Income over Expenditure for the year	4 4 2			
[34 4 2]		£34 4 2	*[34 4 2]*		£34 4 2

No. 7. Property Rehabilitation Fund (incorporating balance of the Herbert Spencer Bequest Fund)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost:	
	£398 4s. 3d. 3 per cent. London County Consolidated Stock, 1956/61	400 0 0
	[Value of stocks at 31/3/42, £398 4s. 3d.] (Value at 31/3/43, £402 3s. 10d.)	
[400 0 0]		£400 0 0
	Cash balance overdrawn	£7 13 11

	EXPENDITURE	£ s. d.		INCOME	£ s. d.
	To Air Raid Precautions at Down House	13 6		By Interest	5 19 5
	„ Air Raid Precautions at Burlington House	37 6 11		„ Income Tax recovered	5 19 5
				„ Balance, being excess of Expenditure over Income for the year	26 1 7
[79 12 10]		£38 0 5	*[79 12 10]*		£38 0 5

No. 8. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£248 17*s.* 8*d.* 3 per cent. London County Consolidated Stock, 1956/61	250 0 0
[*Value of stock at 31/3/42, £248 17s. 8d.*]	(Value at 31/3/43, £251 6*s.* 5*d.*)	
[*250 0 0*]		£250 0 0
	Cash at bank	£10 15 3

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Balance, being Income for the year . .	7 9 4	By Interest	3 14 8
		„ Income Tax recovered	3 14 8
[*6 18 1*]	£7 9 4	[*6 18 1*]	£7 9 4

No. 9. Down House

In response to an appeal made in 1927 by Sir Arthur Keith, F.R.S., then President of the British Association, Mr. (now Sir) Buckston Browne, F.R.C.S., acquired the property of Down House, formerly the home of Darwin, and transferred it with an endowment of £20,000 to the Association as a gift to be held as a memorial to Darwin in custody for the nation.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	DOWN HOUSE ENDOWMENT FUND	
	£2,500 Commonwealth of Australia 5 per cent. Stock, 1945/75	2,468 19 0
	£3,000 Fishguard and Rosslare Railway and Harbours 3½ per cent. Guaranteed Preference Stock	2,139 17 3
	£2,500 New South Wales 5 per cent. Stock, 1945/65	2,467 7 9
	£2,500 Western Australia 5 per cent. Stock, 1945/75	2,472 1 6
	£3,340 Great Western Railway 5 per cent. Consolidated Guaranteed Stock . .	3,436 7 5
	£2,500 Birkenhead Railway 4 per cent. Consolidated Stock	2,013 9 9
	£7,944 2*s.* 4*d.* 2½ per cent. Consolidated Stock, Inscribed	6,206 15 0
[*Value of stocks, 31/3/42, £24,096 6s. 5d.*]	(Value at 31/3/43, £24,272 2*s.* 8*d.*)	
[*21,204 17 8*]		£21,204 17 8
	Cash at bank and in hand . . .	£115 3*s.* 2*d.*

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Wages of Staff	642 15 7½	By Rents receivable	203 0 0
„ Rates, Insurance, etc.	86 3 5	„ Income Tax recovered	373 10 0
„ Electricity	42 4 7	„ Interest and dividends	572 2 0
„ Fuel	118 8 0	„ Sale of postcards	1 0
„ Drainage Plant	16 1 6	„ Amount transferred from Property Rehabilitation Fund on Air Raid Precautions account	13 6
„ Water	19 15 9		
„ Repairs and Renewals	36 0 4		
„ Land and Garden: materials and maintenance	71 12 8½		
„ Donations to village institutions . . .	5 5 0		
„ Household requisites, etc.	10 13 5		
„ Transport and carriage	12 0		
„ Printing, postage, telephone, stationery .	5 5 4		
„ Air Raid Precautions	13 6		
„ War Damage Insurance (Contents) . .	22 10 0		
„ Legal advice	2 2 0		
„ Balance, being excess of Income over Expenditure for the year, transferred to Suspense Account	69 3 4		
[*1,098 4 4*]	£1,149 6 6	[*1,098 4 4*]	£1,149 6 6

Note.—At the 31st March 1943 there was a liability in respect of War Damage Insurance on Down House, the amount of which has not yet been ascertained.

Schedule of Grants Paid to Research Committees, etc.

during the financial year to March 31, 1943

NOTE.—The year indicated in brackets after the title of each committee is that of its original appointment, and the sum, if any, is that previously expended out of grants by the Association.

	£ s. d.	£ s. d.
1. PAID OUT OF THE GENERAL FUND.		
Insular Faunas (1938 : £30).		10 0 0
2. PAID OUT OF THE CAIRD FUND.		
Bird Behaviour (1938 : £80)	40 0 0	
Plymouth Laboratory (1886 : £1,598 10*s.* 8*d.*) . .	50 0 0	
Freshwater Biological Station (1930 : £862 15*s.* 11*d.*) .	75 0 0	
Algæ and Protozoa (1939 : £75)	25 0 0	
Post-war University Education (1942)	20 0 0	
Prof. D. Burns, towards publication of 'Infant and Maternal Mortality'	20 0 0	
		230 0 0
3. PAID OUT OF CUNNINGHAM BEQUEST FUND (1929).		
Mathematical Tables †		– – –
4. PAID OUT OF THE LEICESTER AND LEICESTERSHIRE FUND, 1933.		
J. L. Crammer, Christ's College, Cambridge . .		30 0 0
5. PAID OUT OF THE BERNARD HOBSON FUND . .		– – –
6. PAID OUT OF MATHEMATICAL TABLES FUND.		
Mathematical Tables †		5 0 0
		£275 0 0

† MATHEMATICAL TABLES.

Total grant paid to March 31, 1943 :—	£ s. d.	£ s. d.
From Cunningham Bequest Fund	2,835 18 11	
„ Caird Fund	1,292 8 2	
„ Mathematical Tables Fund	181 10 0	
„ General Fund	415 17 6	
„ Royal Society Grant (1933)	50 0 0	
	£4,775 14 7	
	£ s. d.	
Amount recovered by sale of tables .	463 8 3	
Amount recovered by hire of accounting machine by Ministry of Supply .	145 1 8	
	608 9 11	
	£4,167 4 8	

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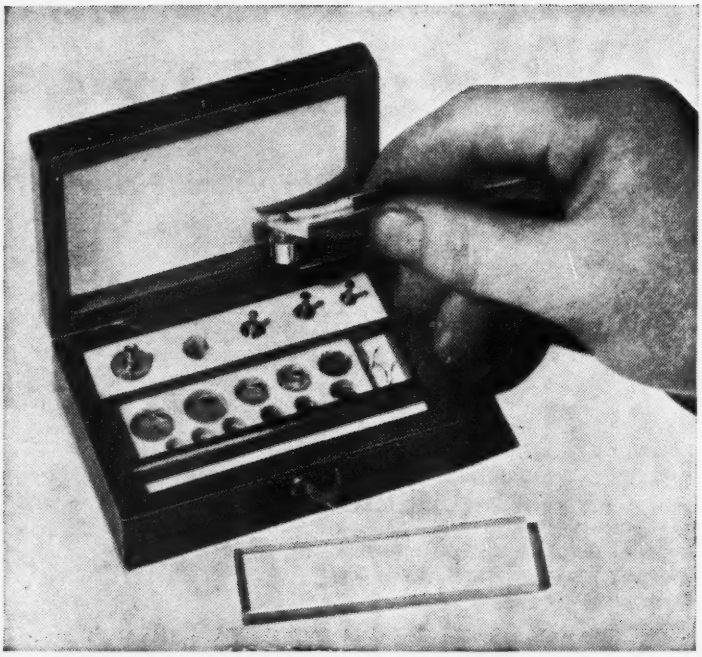

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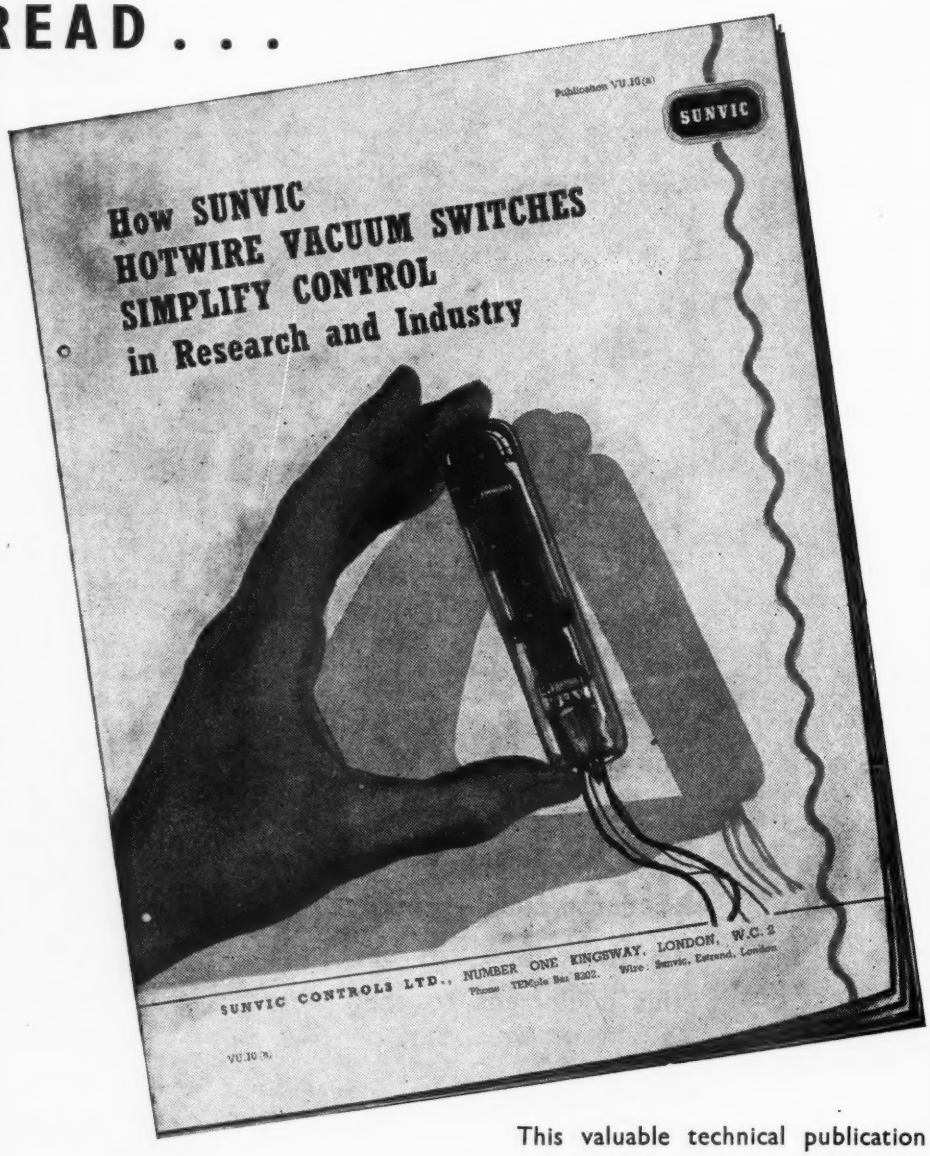

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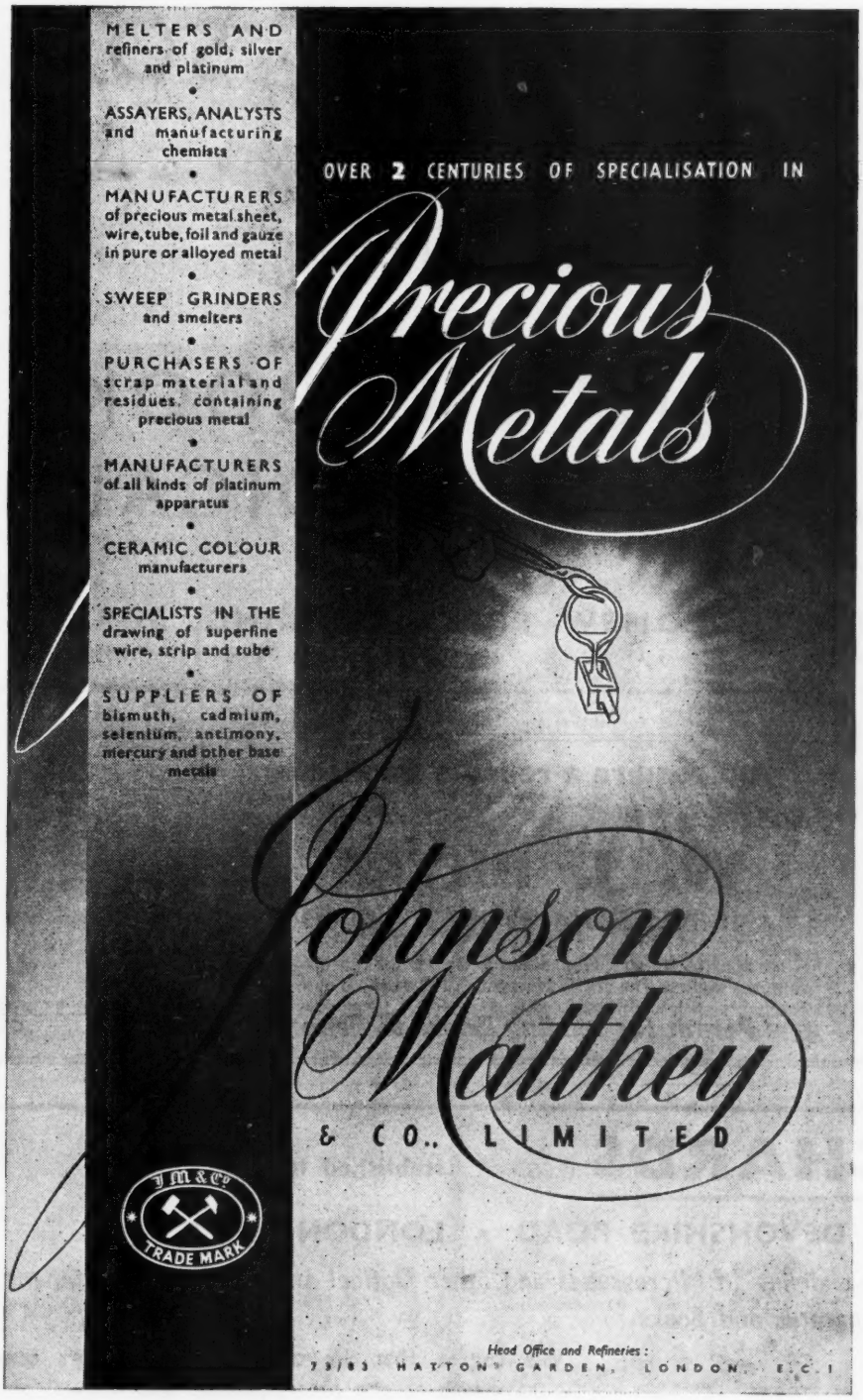
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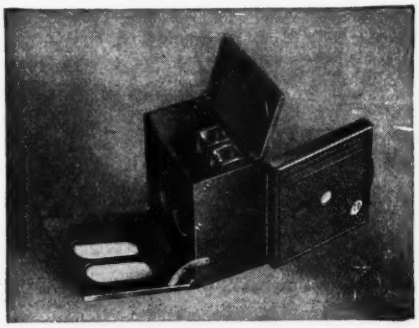

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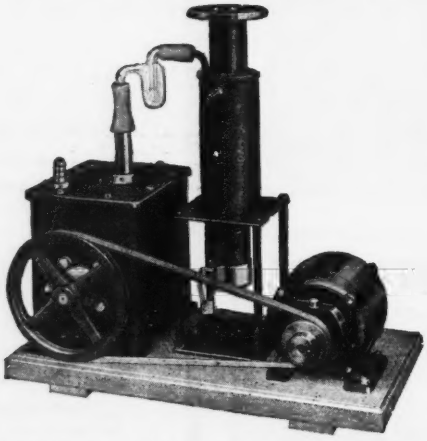

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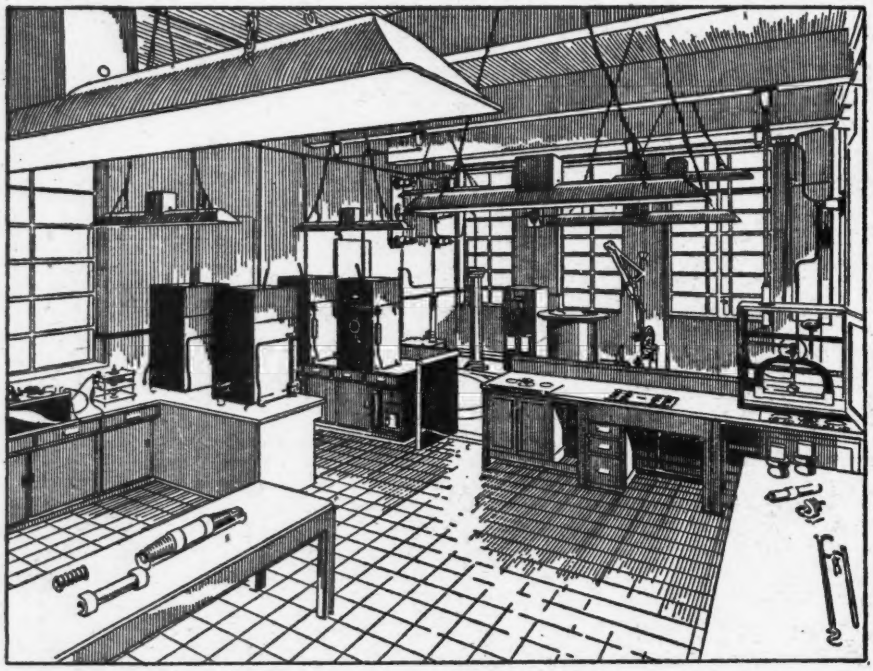

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